

EXHIBIT B

An Evaluation of the Partisan Bias in Michigan's 2011 Districting Plan and its Effects on Representation in Congress and State Government

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1 Introduction

My name is Christopher Warshaw. I have been an Assistant Professor of Political Science at George Washington University since August 2017. Prior to that, I was an Associate Professor at the Massachusetts Institute of Technology from July 2016 - July 2017, and an Assistant Professor at MIT from July 2012 - July 2016.

I have been asked by counsel representing the plaintiffs in *League of Women Voters of Michigan v. Johnson* to analyze relevant data and provide my expert opinions.

More specifically, I have been asked:

- To evaluate the degree of partisan bias in the 2011 congressional and state legislative redistricting plan in Michigan and place the degree of partisan bias in Michigan's plan into historical perspective.
- To evaluate the growing polarization of members of both Congress and state legislatures, and whether that polarization magnifies the effects of gerrymandering.
- To examine the consequences of the 2011 redistricting plan on the representation that Michigan residents receive in Congress and state government.

My opinions are based on the knowledge I have amassed over my education, training and experience, including a detailed review of the relevant academic literature. They also follow from statistical analysis of the following data:

- In order to calculate how gerrymandering affects partisan bias in congressional elections, I examined:
 - A large data set on candidacies and results in Congressional elections: I obtained results from 1972-2014 collected by the Constituency-Level Elections Archive (CLEA) (Kollman et al. 2017). The results from 1972-1990 are based on data collected and maintained by the Inter-university Consortium for Political and Social Research (ICPSR) and adjusted by CLEA. The data from 1992-2014 are based on data collected by CLEA from the Office of the Clerk at the House of the Representatives. I supplemented this dataset with 2016 election results collected by the MIT Election and Data Science Lab (MIT Election and Data Science Lab 2017).
 - Data on presidential election returns and incumbency status in Congressional elections. I used data on elections in congressional districts from 1972-2014 collected by Professor Gary Jacobson (University of California, San Diego).

This dataset has been used in many Political Science studies and has canonical status in the political science profession (Jacobson 2015). For the 2016 election, I used two data sources to supplement Jacobson’s dataset. First, I obtained information on candidates’ incumbency status from Hodges (2016). I obtained data on presidential election returns for the 2016 election aggregated by congressional district from the DailyKos website.

- Information on who controlled each redistricting plan in Congressional elections (e.g., Democrats, Republicans, or a Commission) from 1972-2012 assembled by the Brennan Center (Brennan Center 2017).
- In order to examine the effect of gerrymandering in Congressional elections on representation in Congress, I examined:
 - Data on the roll call voting behavior of members of Congress from the Voteview website maintained by the University of California, Los Angeles (Lewis et al. 2016).
 - Well established estimates of the ideology of members of Congress based on their roll call votes using models originally developed by Professors Keith Poole and Howard Rosenthal (Poole and Rosenthal 1997),¹ and estimates of the percentage of conservative roll call votes cast by each member of Congress developed by Professors Andrew Hall and Anthony Fowler (Fowler and Hall 2017).
 - Information on the congruence of the views of the mass public and the roll call votes of their representatives from the 2016 Cooperative Congressional Election Study (Ansolabehere and Schaffner 2017). This is a large-scale study of how Americans view Congress and hold their representatives accountable during elections, how they voted and their electoral experiences, and how their behavior and experiences vary with political geography and social context (for more information see Vavreck and Rivers 2008; Ansolabehere and Rivers 2013).
 - Information on the mass public’s trust in their Representatives from the 2014 Cooperative Congressional Election Study.
- In order to calculate how gerrymandering affects partisan bias in state legislative elections, I examined:
 - A large canonical data set on candidacies and results in state legislative elections: I obtained results from 1972-2016 collected by Carl Klarner and a large team

1. These DW-Nominate (“ideology”) scores were downloaded from the Voteview website maintained by the University of California, Los Angeles (Lewis et al. 2016).

of collaborators. The results from 1972-2012 are based on data maintained by the Inter-university Consortium for Political and Social Research (ICPSR) (Klarner et al. 2013). The data from 2013-2016 were collected by Klarner.

- Data on presidential election returns in state legislative districts. For elections between 1972 and 1991, I used data on county-level presidential election returns from 1972-1988 collected by the Inter-university Consortium for Political and Social Research (ICPSR 2006) and mapped these returns to state legislative districts. For elections between 1992 and 2001, I used data on presidential election returns in the 2000 election collected by McDonald (2014) and Wright et al. (2009). For elections between 2002 and 2011, I used data on the 2004 and 2008 presidential elections collected by Rogers (2017). For elections between 2012 and 2016, I used data on presidential election returns for the 2012 and 2016 elections from the DailyKos website.
- Information on who controlled each redistricting plan in state legislative elections (e.g., Democrats, Republicans, or a Commission) from 1972-2012 assembled by Stephanopoulos (2018).
- In order to examine the effect of gerrymandering in state legislative elections on representation in state government, I examined:
 - Well established estimates of the ideology of state legislators based on their roll call votes developed by Professors Nolan McCarty and Boris Shor (Shor and McCarty 2011).²
 - Estimates of the policy liberalism of state governments based on nearly 150 policies using a model I developed in a co-authored paper which was published in the *American Journal of Political Science* (Caughey and Warshaw 2016).³

2 Qualifications, Publications and Compensation

My Ph.D. is in Political Science, from Stanford University, where my graduate training included courses in political science and statistics. I also have a J.D. from Stanford Law School. My academic research focuses on public opinion, representation, elections, and polarization in American Politics. My curriculum vitae is attached to this report. All publications that I have authored and published appear in my curriculum vitae. My work

2. These scores were downloaded from the Harvard Dataverse website.

3. These scores were downloaded from the Harvard Dataverse website.

is published or forthcoming in peer-reviewed journals such as: the *American Political Science Review*, the *American Journal of Political Science*, the *Journal of Politics*, *Political Analysis*, *Political Science Research and Methods*, the *British Journal of Political Science*, *Political Behavior*, the *Election Law Journal*, *Nature Energy*, *Public Choice*, and edited volumes from Cambridge University Press and Oxford University Press. I am also on the Editorial Board of the *Journal of Politics*. I have previously provided an expert report in *League of Women Voters of Pennsylvania v. Commonwealth of Pennsylvania*. My non-academic writing has been published in the New York Times Upshot. I am being compensated at a rate of \$275 per hour.

3 Summary

A key attribute of democracy, if not its very definition, is “responsiveness of the government to the preferences of its citizens, considered as political equals” (Dahl 1971, 1; May 1978). The relationship between the distribution of partisan support in the electorate and the partisan composition of the government—what Powell (2004) calls “vote–seat representation”—is a critical link in the longer representational chain between citizens’ preferences and governments’ policies. If the relationship between votes and seats systematically advantages one party over another, then some citizens will enjoy more influence—more “voice”—over political outcomes than others.

This report examines four distinct questions related to how Michigan’s 2011 redistricting plan affects citizens’ representation in the political process. First, it measures the partisan bias in Michigan’s 2011 congressional districting plan and places it into historical perspective. Second, it examines polarization in Congress and how that magnifies the effect of partisan bias in the redistricting plan on the representation that citizens receive from their elected officials. Third, it measures the partisan bias in Michigan’s state legislative districting plan and places it into historical perspective. Finally, it examines the effect of partisan bias in the redistricting plan on the representation that Michigan’s citizens receive in state government. Based on this analysis, I reach the following conclusions.

- *Michigan’s 2011 redistricting plan does indeed disadvantage one party compared to the other, and does so in ways that are historically extreme.* There are substantially more wasted Democratic votes in Michigan congressional and state legislative elections than Republican votes. This has led to a substantial and durable pro-Republican bias in the translation of votes to seats in congressional and state legislative elections in Michigan. One simple metric to capture the ratio of wasted

votes by each party is called the “Efficiency Gap.” In recent elections, Michigan has had a pro-Republican Efficiency Gap that is extreme relative to both its own historical Efficiency Gaps, and the Efficiency Gap in other states. The Efficiency Gaps in Michigan in the past three elections were among the most Republican-leaning Efficiency Gaps the nation has ever seen. Michigan’s congressional districts had a larger pro-Republican bias after its 2011 redistricting plan took effect in 2012 than 98% of the congressional election maps over the past 45 years. Its state house districts were also more pro-Republican than 98% of previous plans and its state senate districts were more pro-Republican than 99.7% of previous plans over the past five decades. It exhibited a similarly large pro-Republican bias using other quantitative measures of gerrymandering, such as the mean-median and declination metrics (Krasno et al., forthcoming; Best et al. 2017; Warrington 2018). Moreover, recent Efficiency Gaps are quite durable. This suggests that partisan gerrymandering is unlikely to be remedied through the normal electoral process.

- *The pro-Republican advantage in congressional elections in Michigan has important representational consequences for voters.* Due to the growing polarization in Congress and state legislatures, there is a massive difference between the roll call voting behavior of Democrats and Republicans. Thus, Democratic voters whose votes are wasted in Michigan are unlikely to see their preferences represented in our nation’s capital. They effectively have no political voice. This has led voters in gerrymandered states to trust their representatives less than voters in non-gerrymandered states. This suggests that gerrymandering is eroding Americans’ faith in our democracy.
- *The pro-Republican advantage in state legislative elections in Michigan also has important representational consequences for voters.* It has led the roll call voting patterns and, in all likelihood, the policies passed by Michigan’s government to be much more conservative than they would have been if Michigan had a neutral Efficiency Gap.

4 Background on Partisan Gerrymandering

The goal of partisan gerrymandering is to create legislative districts that are as “efficient” as possible in translating a party’s vote share into seat share (McGhee 2014, 2017; Caughey, Tausanovitch, and Warshaw 2017). In practice, this entails drawing districts in which the supporters of the advantaged party constitute either a slim majority (e.g., 55%

of the two-party vote) or a small minority (e.g., 20%). The former is achieved by “cracking” local opposing-party majorities across multiple districts and the latter by “packing” them into a few overwhelming strongholds. Both types of districts “waste” more votes of the disadvantaged party than of the advantaged one. This suggests that gerrymandering can be measured based on the number of wasted votes for each party.

In a “cracked” district, the disadvantaged party narrowly loses, wasting a large number of votes without winning a seat. In a “packed” district, the disadvantaged party wins overwhelmingly, wasting a large number of votes above the 50%+1 needed to win. The resulting asymmetry in the efficiency of the vote–seat relationships of the two parties lies at the core of normative and constitutional critiques of partisan gerrymandering.

There are a number of approaches that have been proposed to measure asymmetries in the efficiency of the vote–seat relationships of the two parties. In recent years, at least 10 different approaches have been proposed (McGhee 2017). While no measure is perfect, much of the recent literature has used a simple yet powerful way to operationalize this concept of partisan gerrymandering called the *Efficiency Gap* (EG) (McGhee 2014; Stephanopoulos and McGhee 2015; Caughey, Tausanovitch, and Warshaw 2017; Brennan Center 2017; Chen 2017; Stephanopoulos 2018). I use this metric as the primary tool to measure partisan bias in a districting plan. However, I also use two other metrics throughout this report to show that my conclusions about the historically large level of partisan bias in Michigan’s plan are robust to the precise measure of gerrymandering that we use.

4.1 Measuring Gerrymandering using the Efficiency Gap

The Efficiency Gap (EG) focuses squarely on the number of each party’s wasted votes in each election. It is defined as “the difference between the parties’ respective wasted votes, divided by the total number of votes cast in the election” (Stephanopoulos and McGhee 2015, 831; see also McGhee 2014, 2017).⁴ All of the losing party’s votes are wasted if they

4. The Efficiency Gap calculations here focus on wasted votes in *legislative elections* since these results directly capture voters’ preferences in these elections. However, we might also calculate the Efficiency Gap using district-level results from presidential elections or other statewide races. These have the “advantage of being (mostly) unaffected by district-level candidate characteristics” (Stephanopoulos and McGhee 2015, 868). This feature is particularly useful for simulating Efficiency Gaps from randomly generated districting plans since candidate characteristics are clearly influenced by the final districting plan. Presidential elections or other statewide races are less closely tied, however, to voters’ preferences in legislative races given the district lines that actually exist. In practice, though, both legislative races and other statewide races produce similar Efficiency Gap results for modern elections where voters are well sorted by party and ideology. Indeed, the data indicate that the correlation between Efficiency Gap estimates based on congressional elections and presidential elections is approximately 0.8 for elections held after 2000 and 0.9 for elections held after the 2011 redistricting cycle.

lose the election. When a party wins an election, the wasted votes are those above the 50%+1 needed to win.

If we adopt the convention that positive values of the Efficiency Gap imply a Democratic advantage in the districting process and negative ones imply a Republican advantage, the Efficiency Gap can be written mathematically as:

$$EG = \frac{W_R}{n} - \frac{W_D}{n} \quad (1)$$

where W_R are wasted votes for Republicans, W_D are wasted votes for Democrats, and n is the total number of votes in each state.

Table 1 provides a simple example about how to calculate the Efficiency Gap with three districts where the same number of people vote in each district. In this example, Democrats win a majority of the statewide vote, but they only win 1/3 seats. In the first district, they win the district with 75/100 votes. This means that they only wasted the 24 votes that were unnecessary to win a majority of the vote in this district. But they lose the other two districts and thus waste all 40 of their votes in those districts. In all, they waste 104 votes. Republicans, on the other hand, waste all 25 of their votes in the first district. But they only waste the 9 votes unnecessary to win a majority in the two districts they win. In all, they only waste 43 votes. This implies a pro-Republican Efficiency Gap of $\frac{43}{300} - \frac{104}{300} = -20\%$.

Table 1: Illustrative Example of Efficiency Gap

District	Democratic Votes	Republican Votes
1	75	25
2	40	60
3	40	60
Total	155 (52%)	145 (48%)
Wasted	104	43

In order to account for unequal population or turnout across districts,⁵ the Efficiency Gap formula in equation 1 can be rewritten as:

$$EG = S_D^{margin} - 2 * V_D^{margin} \quad (2)$$

where S_D^{margin} is the Democratic Party's seat margin (the seat share minus 0.5) and V_D^{margin} is the Democratic Party's vote margin. V_D^{margin} is calculated by aggregating the raw

5. See the National Conference of State Legislatures' 2010 Redistricting Deviation Table which shows the extent to which populations of all the districts in a plan vary, or differ collectively from the ideal equipopulous districts. <http://www.ncsl.org/research/redistricting/2010-ncsl-redistricting-deviation-table.aspx>.

votes for Democratic candidates across all districts, dividing by the total raw vote cast across all districts, and subtracting 0.5 (McGhee 2017, 11-12). In the example above, this equation also provides an Efficiency Gap of -20% in favor of Republicans. But it could lead to a slightly different estimate of the Efficiency Gap if districts are malapportioned or there is unequal turnout across districts.⁶

The Efficiency Gap mathematically captures the packing and cracking that are at the heart of partisan gerrymanders. A key advantage of the Efficiency Gap over other measures of partisan bias is that it can be calculated directly from observed election returns even when the parties' statewide vote shares are not equal. In either case, the Efficiency Gap measures the extra seats one party wins over and above what would be expected if neither party were advantaged in the translation of votes to seats (i.e., if they had the same number of wasted votes).

In the analysis that follows, I examine the historical trajectory of the Efficiency Gap in Michigan and the nation as a whole. For all legislative elections that were contested between two major party candidates, I use the raw vote totals for the Efficiency Gap calculation. For legislative elections that are uncontested (i.e., those that lacked either a Democratic or Republican candidate), we do not directly observe the number of people that support each party's candidate. In these cases, it is necessary to estimate the two-party vote share because "determining the degree of packing and cracking requires knowing how many people in each district support each party" (Stephanopoulos and McGhee 2015, 865). Using publicly available data and statistical models, I estimate the two-party vote share in each district based on previous and future elections in that district as well as the results in similar districts elsewhere. This is similar to the approach used in a variety of other studies that estimate either the Efficiency Gap (Stephanopoulos and McGhee 2015; Brennan Center 2017; Jackman 2017; McGhee 2018) or some other gerrymandering metric (e.g., Warrington 2018). The details of this calculation for uncontested races are described in further detail in the Appendix.

Now that we know voters' two-party preferences in contested districts and we have estimates of their preferences in uncontested districts, we are finally in position to estimate the partisan advantage in the legislative districting process during each state-year. I estimate the Efficiency Gap in the congressional and state legislative elections of nearly all states for each election between 1972 to 2016.⁷

6. In general, the two formulations of the Efficiency Gap formula yield very similar results. Because Democrats tend to win lower-turnout districts, however, the turnout adjusted version of the Efficiency Gap in equation 2 tends to produce results that suggest about a 2% smaller disadvantage for Democrats than the version in Equation 1 (see McGhee 2018).

7. I start the analysis in 1972 since those are the first districting plans drawn after the Supreme Court cases stemming from *Baker v. Carr* ended malapportionment and established the principle of one-person,

4.2 Other Measures of Partisan Bias in Districting Plans

In addition to the Efficiency Gap, a number of other statistical approaches have been proposed to measure partisan bias in a redistricting plan (e.g., Gelman and King 1994a, 1994b). All of these approaches have important strengths and weaknesses (McGhee 2014, 2017). Overall, I believe that the Efficiency Gap is the best measure of partisan bias in the districting process. However, I also use two alternative measures of gerrymandering throughout this report to show that my conclusions about the extremity of Michigan's plan are robust to the precise measure of gerrymandering that we use.

1. **Mean-median:** Some scholars have proposed that partisan bias in a districting plan can be measured using the difference between a party's vote share in the median district and their average vote share across all districts. If the party wins more votes in the median district than in the average district, they have an advantage in the translation of votes to seats (Krasno et al., forthcoming; Best et al. 2017). The mean-median difference is very easy to apply (Wang 2016). It is possible, however, for packing and cracking to occur without any change in the mean-median difference. That is, a party could gain seats in the legislature without the mean-median gap changing (McGhee 2017).⁸ It is also sensitive to the outcome in the median district (Warrington 2018). Finally, the mean-median difference lacks an obvious interpretation in terms of the number of seats that a party gains through gerrymandering.

Table 2 illustrates the mean-median approach using the district-level election results in the 2012 Michigan congressional elections. It indicates that many Democratic voters were packed into just 5 districts where the Democratic candidates won by overwhelming margins. The remaining Democratic voters were cracked across the other 9 districts, several of which were decided by very close margins. This table shows the disproportionate percentage of the statewide vote that Democrats would have needed to win a majority of Michigan's congressional seats in 2012.⁹ Across

one-vote. Also, I validate my measures of the Efficiency Gap to make sure that they align closely with Efficiency Gaps calculated using alternative modeling approaches for uncontested races. In the Appendix, I show that my estimates of the Efficiency Gap are extremely highly correlated with a variety of other measures of the Efficiency Gap developed using different assumptions for the imputation of uncontested districts.

8. As McGhee (2017), notes, "If the median equals the win/loss threshold—i.e., a vote share of 0.5—then when a seat changes hands, the median will also change and the median-mean difference will reflect that change. But if the median is anything other than 0.5, seats can change hands without any change in the median and so without any change in the median-mean difference."

9. Democrats would have needed to win the 3rd District to win a majority of seats, and Democrats would have needed to win an additional 4.5% of the vote there to win—even though Democrats already

all districts, Democrats won an average of 53% of the vote. But they only won 46.1% in the median district (e.g., the median between the 3rd and 11th districts). As a result, Democrats lost at least two districts that they would have won if there was no difference between the mean and median districts. This translates into a mean-median difference in Michigan’s 2012 election of 6.9%.

District	Democratic Vote Share
10	30.2%
04	34.7%
02	35.9%
08	38.9%
06	43.8%
07	44.6%
03	45.6%
11	46.6%
01	49.7%
09	64.5%
05	67.4%
12	70.1%
14	84%
13	85.9%
Mean	53%
Median	46.1%

Table 2: Results in 2012 Michigan Congressional Elections

2. **Declination:** The declination metric starts from the assumption that a plan drawn with the intent to advantage one party will arrange the distribution of district vote shares in a way that treats the 50 percent threshold for victory differently than other vote values (Warrington 2018).¹⁰ In the absence of partisan intent, if all the districts in a plan are lined up from the least Democratic to the most Democratic, the mid-point of the line formed by one party’s seats should be about as far from 50 percent on average as the other party’s (McGhee 2018). When this condition is not met, the distribution might look more like the one in Figure 1, which shows the actual 2012 congressional results in Michigan. The districts won by Republicans (in red) are much closer to 50 percent than the ones won by Democrats (in blue).¹¹

won 53.0% of the vote in the average district. In other words, Democrats would have needed to win about 57.5% of the vote to win a majority of the seats in Michigan’s congressional delegation.

10. This discussion is adapted from the excellent summary of declination in McGhee (2018).

11. District numbers are shown for each result.

This distribution appears to be designed to ensure that Republican seats do not cross the 50 percent line, in part by packing the Democratic voters into a handful of seats.

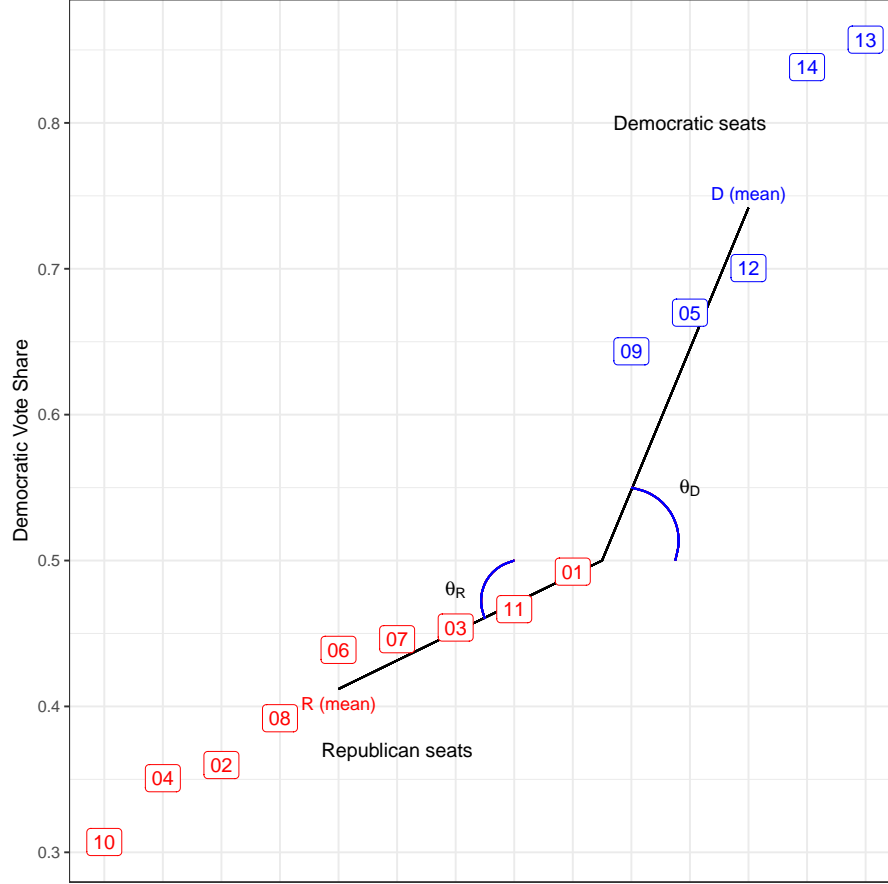


Figure 1: Declination in Michigan's 2012 Congressional Elections.

Declination suggests that when a plan is not deliberately drawn to favor one party, the angles of the lines (θ_D and θ_R) between the mean across all districts and the point on the 50% line between the mass of points representing each party will be roughly equal. When they deviate from each other, the smaller angle (θ_R in the case of Michigan) will generally identify the favored party. To capture this idea, declination takes the difference between those two angles (θ_D and θ_R) and divides by $\pi/2$ to convert the result from radians to fractions of 90 degrees.¹² This produces a number between -1 and 1. As calculated here, positive values favor Democrats and negative values favor Republicans.¹³ Warrington (2018) suggests a further adjustment to

12. This equation is: $\delta = 2 * (\theta_R - \theta_D) / \pi$.

13. In order to validate my estimates of declination, I compare my estimates to the ones presented in Warrington (2018). I find that my declination estimates are nearly identical to the estimates originally

account for differences in the number of seats across legislative chambers. I use this adjusted declination estimate in the analysis that follows.¹⁴

A weakness of the declination approach vis-a-vis the Efficiency Gap is that declination lacks a clear interpretation in terms of the number of seats that a party gains through gerrymandering. It is also somewhat unstable when a party holds a very small number of seats in the legislature. However, some scholars have claimed that it represents a better measure of intent in the gerrymandering process than the Efficiency Gap (McGhee 2018). Moreover, it is arguably less sensitive to the outcome of a handful of close elections than the Mean-Median difference or the Efficiency Gap (Warrington 2018). In practice, though, the declination measure, $\hat{\delta}$, and the Efficiency Gap are highly correlated. The correlation between them is about .82 for congressional elections, .86 for state house elections, and .82 for state senate elections.

5 Gerrymandering in Congressional Districts

In this section, I will first provide an historical overview of the Efficiency Gap in congressional districts over the past 45 years. Next, I will show that Michigan's 2011 redistricting plan is historically extreme compared to both other states and its own plans in previous decades. Finally, I will show that partisan bias in congressional districts has real consequences for the representation that citizens receive in Congress.

5.1 Efficiency Gap in Congress

Figure 2 shows the distribution of Efficiency Gaps between 1972 and 2016 in states with more than 6 congressional seats.¹⁵ It shows the relative proportion of states with different values of the Efficiency Gap. The Efficiency Gap in each election year is represented in the distribution.

developed by Warrington in the appendix to his article. In fact, the correlation between the declination values that I calculate and those in Warrington (2018) is .94 for the U.S. House and .96 for state house elections (note that Warrington does not estimate declination values for state senate elections). Small differences between the declination estimates likely stem from minor differences in how we impute vote shares in uncontested races.

14. This adjustment uses this equation: $\hat{\delta} = \delta * \ln(\text{seats}) / 2$

15. I focus on states with more than 6 congressional seats for two reasons. First, these states contribute less to the overall distribution of seats in Congress (Stephanopoulos and McGhee 2015, 868). Second, the Efficiency Gap in smaller states tends to be more volatile and thus less informative about partisan bias. For example, in a state with only three seats, a change in the winner of one seat could cause a huge shift in their Efficiency Gap.

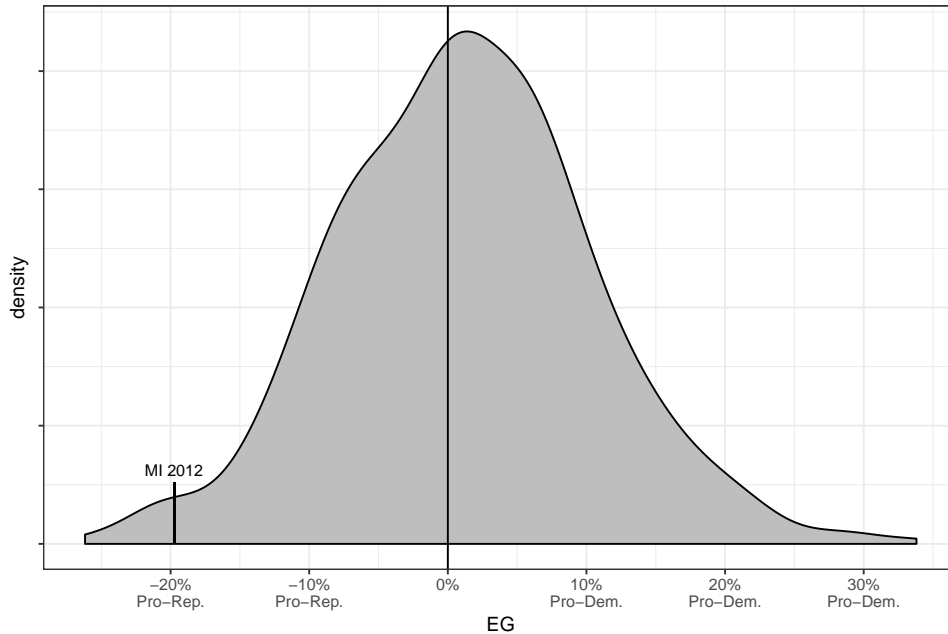


Figure 2: National Distribution of Efficiency Gaps for Congressional Elections in States with More than 6 Seats: 1972-2016. Michigan's 2012 Efficiency Gap is shown on the bottom-left of the plot.

This figure illustrates several important facts. First, it indicates that over this entire period the average state had a slightly Democratic leaning Efficiency Gap.¹⁶ Second, it indicates that the bulk of Efficiency Gaps are small. In fact, roughly 75% of Efficiency Gaps lie between -10% and 10%. Only about 4% of state-level Efficiency Gaps have more than a 20% advantage for either party. Third, it graphically illustrates that Michigan's post-2011 congressional district plan had one of the largest values of the Efficiency Gap in history.

5.1.1 Historical Trajectory of the Efficiency Gap in Congress

Next, I examine the historical trajectory of the Efficiency Gap. Figure 3 shows the average Efficiency Gap in states with more than 6 congressional seats between 1972 and 2016. The vertical bars delineate changes in the decennial districting plans.

The plot indicates that the average Efficiency Gap was slightly Democratic leaning in the 1970s and 1980s. This is consistent with a wide array of evidence from other Political Science studies showing that Democrats had a modest advantage from the districting process during this period (e.g., King and Gelman 1991; Cox and Katz 2002; Stephanopoulos and McGhee 2015). Indeed, Cox and Katz (2002) show that Democratic control of the

16. Stephanopoulos and McGhee (2015, 870) reach similar findings.

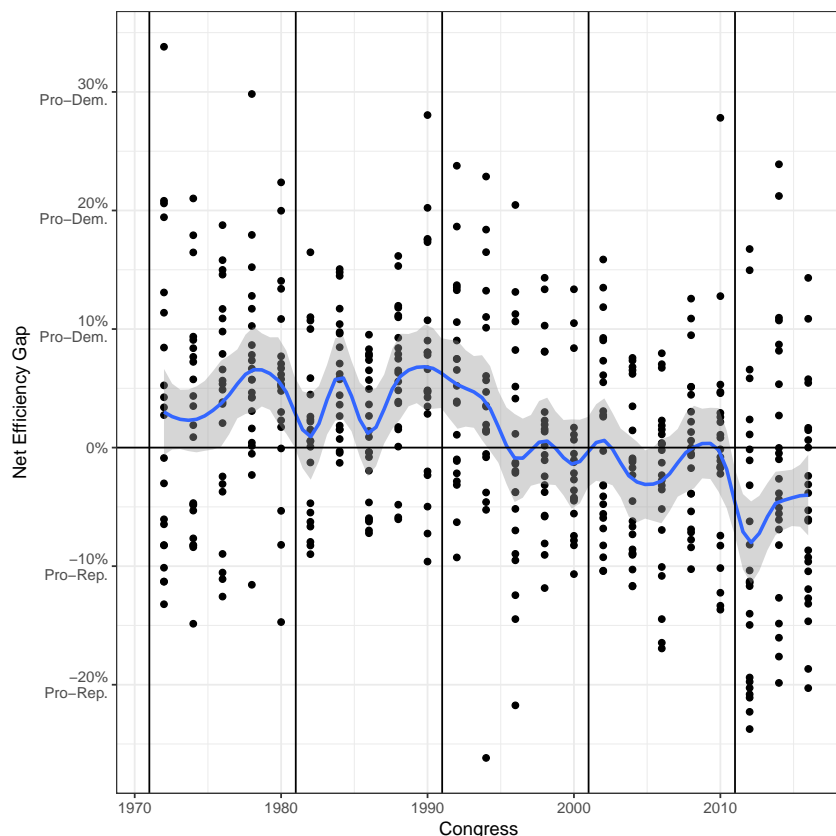


Figure 3: Historical Trajectory of the Efficiency Gap. Each vertical line shows the demarcation between decennial redistricting plans. The line shows the moving average and the grey bar is a confidence interval. The dots represent the Efficiency Gaps in individual states.

redistricting process in many states during the reapportionment revolution in the 1960s led to a lasting net partisan advantage for Democrats in House elections. This advantage dissipated though by the end of the 1980s. In the 1990s, neither party had a significant net-advantage in the Efficiency Gap. In the first half of the 2000s, Republicans developed a very small advantage because they wasted fewer votes than Democrats (see also Kastellec, Gelman, and Chandler 2008; Stephanopoulos and McGhee 2015).

After the most recent redistricting in 2012, Republicans advantage grew significantly. Put simply, they abruptly developed a very substantial net advantage in the translation of congressional votes to seats (see also Brennan Center 2017; Stephanopoulos and McGhee 2015, 127). My calculations indicate that the average Efficiency Gap went from approximately 0 in 2010 to an average Republican advantage of 8 percentage points in the two years between 2010 and 2012 when the new districts came into effect. According to one recent report, the change in Efficiency Gaps during this period corresponds to a

net Republican advantage of approximately 16-17 seats in the House of Representatives (Brennan Center 2017). Moreover, the sharpness of the change in the Efficiency Gap between 2010 and 2012 makes it unlikely to have been caused by geographic changes or non-political factors.

5.1.2 Partisan Control of the Redistricting Process and the Efficiency Gap

Of course, the Efficiency Gap can be non-zero and differ across states for reasons unrelated to the drawing of district lines, such as variation in how different demographic groups are distributed across geographic space (Chen and Rodden 2013). The Efficiency Gap can also be affected by the intentional drawing of district lines to accomplish goals other than maximizing partisan seat share, such as ensuring the representation of racial minorities (e.g., Brace, Grofman, and Handley 1987).

There is a wide body of evidence, however, from previous political science studies that control of the redistricting process influences the partisan balance in subsequent elections. Cox and Katz (2002) show that Democratic control of the redistricting process in many states during the 1960s led to a lasting partisan advantage for Democrats in House elections. More generally, Gelman and King (1994b) find that the party in control of redistricting shifts outcomes in its favor, and that “the effect is substantial and fades only very gradually over the following 10 years” (543). This result has been confirmed in numerous recent articles. McGhee (2014) finds that “parties seek to use redistricting to shift bias in their favor and that they are successful in these efforts” (74).¹⁷ Finally, in a comprehensive analysis of congressional elections over the past forty years, Stephanopoulos (2018) shows that partisan control of the districting process has a substantial effect on the Efficiency Gap. He shows that states with unified Republican control have about 5 percentage points more pro-Republican Efficiency Gaps than states with split control, and states with unified Democratic control have about 3 percentage points more pro-Democratic Efficiency Gaps than states with split control. While most of these studies focus on historical analysis, my own analysis indicates that control of the redistricting process in 2011 had a large impact on the Efficiency Gap in the past few elections. Overall, both the studies discussed above and my own independent analysis strongly suggest that political control of redistricting continues to have large and durable effects on partisan bias in the districting plans. Moreover, partisan control of government is highly correlated with changes in the Efficiency Gap.

17. It is worth noting that McGhee (2014) finds that partisan control affects the districting process using both the Gelman and King (1994b) measure of partisan symmetry and the Efficiency Gap as outcome variables.

5.1.3 Durability of the Efficiency Gap in Congress

In this section, I examine the durability of the Efficiency Gap. Put differently, how well does the Efficiency Gap immediately after the decennial redistricting predict subsequent Efficiency Gaps?

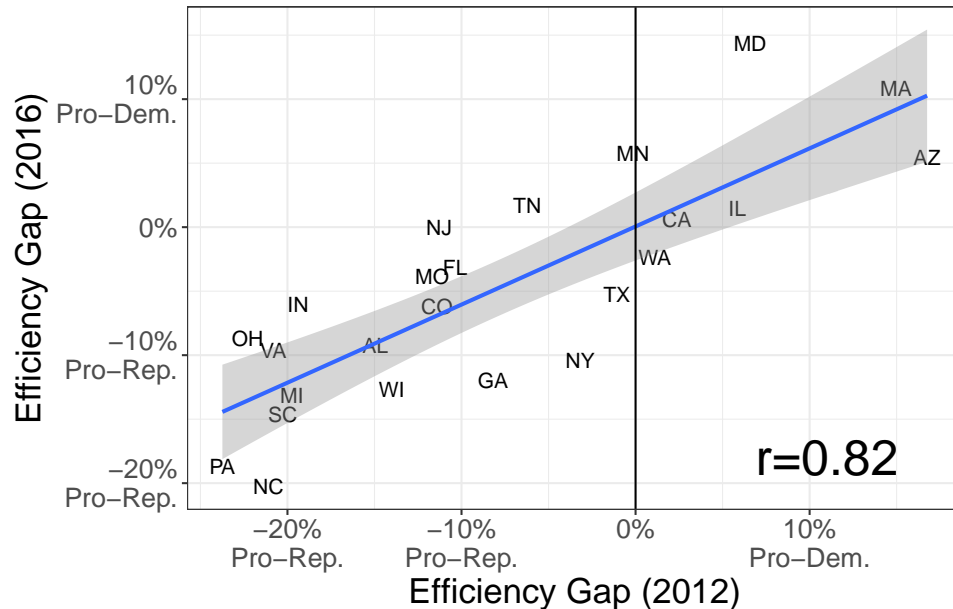


Figure 4: Durability of Efficiency Gap. This graph compares Efficiency Gaps in 2012 and 2016. It shows that recent Efficiency Gaps are durable.

Figure 4 shows that the Efficiency Gaps stemming from the 2011 redistricting have been durable. For example, it shows that in North Carolina, the efficiency gap was -21% in 2012 and -20% in 2016, in Wisconsin, it was -13% in 2012 and -14% in 2016, and in Michigan, it was -19.7% in 2012 and -13.2% in 2016. Overall, there is a 0.82 correlation between the Efficiency Gaps in states with more than 6 seats in 2012 and the Efficiency Gaps four years later in 2016. This means that the 2012 Efficiency Gaps predict 67% of the variation in the Efficiency Gaps four years later. Moreover, Michigan's Efficiency Gap in 2016 was similar to its Efficiency Gap in 2012. This analysis shows that recent Efficiency Gaps are durable, and thus partisan gerrymandering is unlikely to be remedied through the normal electoral process.

5.1.4 Efficiency Gap in Michigan's Congressional Districts

The previous section showed trends in the nationwide trajectory of the Efficiency Gap. In this section, I focus on the Efficiency Gap in Michigan. My analysis indicates that in recent elections, Michigan has had a pro-Republican Efficiency Gap that is extreme

relative to both its own historical Efficiency Gaps, and the Efficiency Gap in other states. In fact, the Efficiency Gaps in Michigan in the past three elections were among the most Republican-leaning Efficiency Gaps the nation has ever seen.

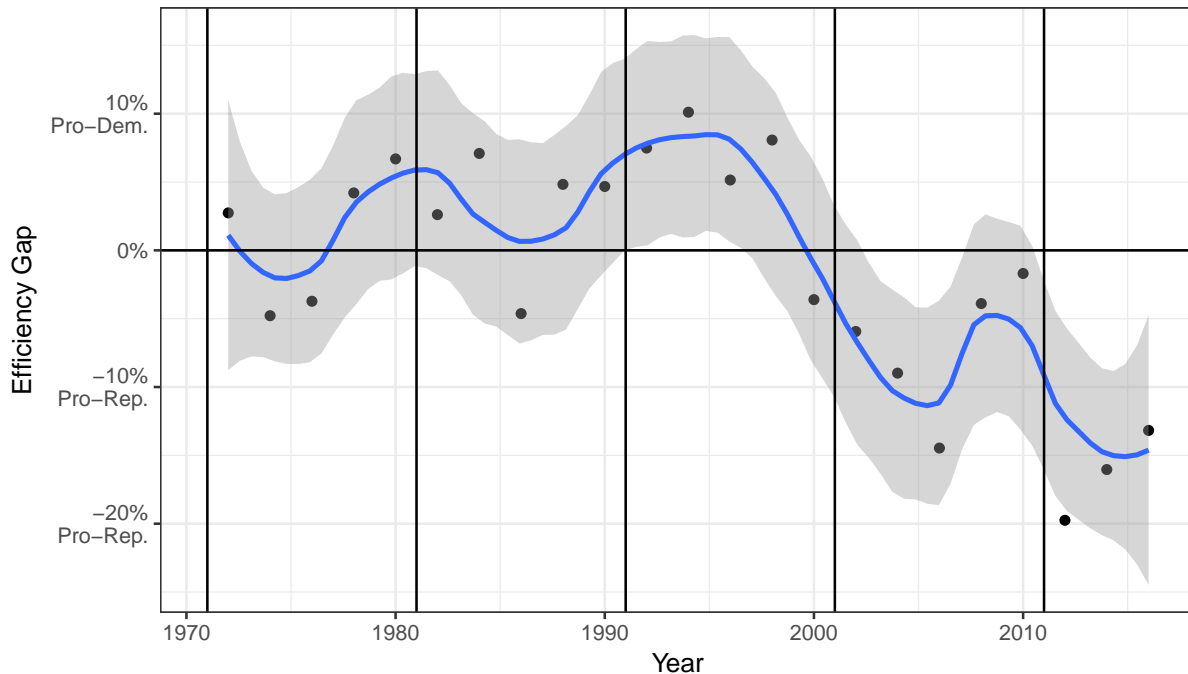


Figure 5: Historical Trajectory of the Efficiency Gap in Michigan. Each vertical line shows the demarcation between decennial redistricting plans. The blue line shows the moving average and the grey bar is a confidence interval. The dots represent the Efficiency Gaps in each year in Michigan.

Figure 5 shows trends in the Efficiency Gap in Michigan between 1972 and 2016. Michigan had a modestly pro-Democratic Efficiency Gap in the 1970s and 1990s. From about 2002 through 2010 Republicans had a modest advantage in the Efficiency Gap in Michigan, perhaps because they controlled the redistricting in 2001. However, the 2011 redistricting plan led to a large Republican advantage in Michigan congressional elections unlike what the state experienced after previous redistricting periods.

After being relatively neutral for the past three decades, Michigan's congressional map developed a large and persistent pro-Republican Efficiency Gap after the 2011 redistricting. In 2012, Democrats wasted over 1.5 million votes, while Republicans only wasted about 650,000 votes. As a result of their greater efficiency at translating votes into seats, Republican candidates won only 47.3% of the statewide congressional vote, but they won 9 of 14 – or 64.3% – of Michigan's congressional seats. This led to a huge pro-Republican Efficiency Gap of approximately 19.7%.

The results in the next two elections were similar to those in 2012. In 2014 and

2016, Republican candidates retained the same 64.3% share of Michigan's seats, even while losing the statewide vote in 2014 and only narrowly winning it in 2016. This corresponded to an Efficiency Gap of approximately -16% in 2014 and -13.2% in 2016. These Efficiency Gaps imply that Republicans in Michigan won 2-3 more seats in these elections than they would have won if Michigan had no partisan bias in its Efficiency Gap (see also Stephanopoulos and McGhee 2015; Brennan Center 2017, for similar estimates).

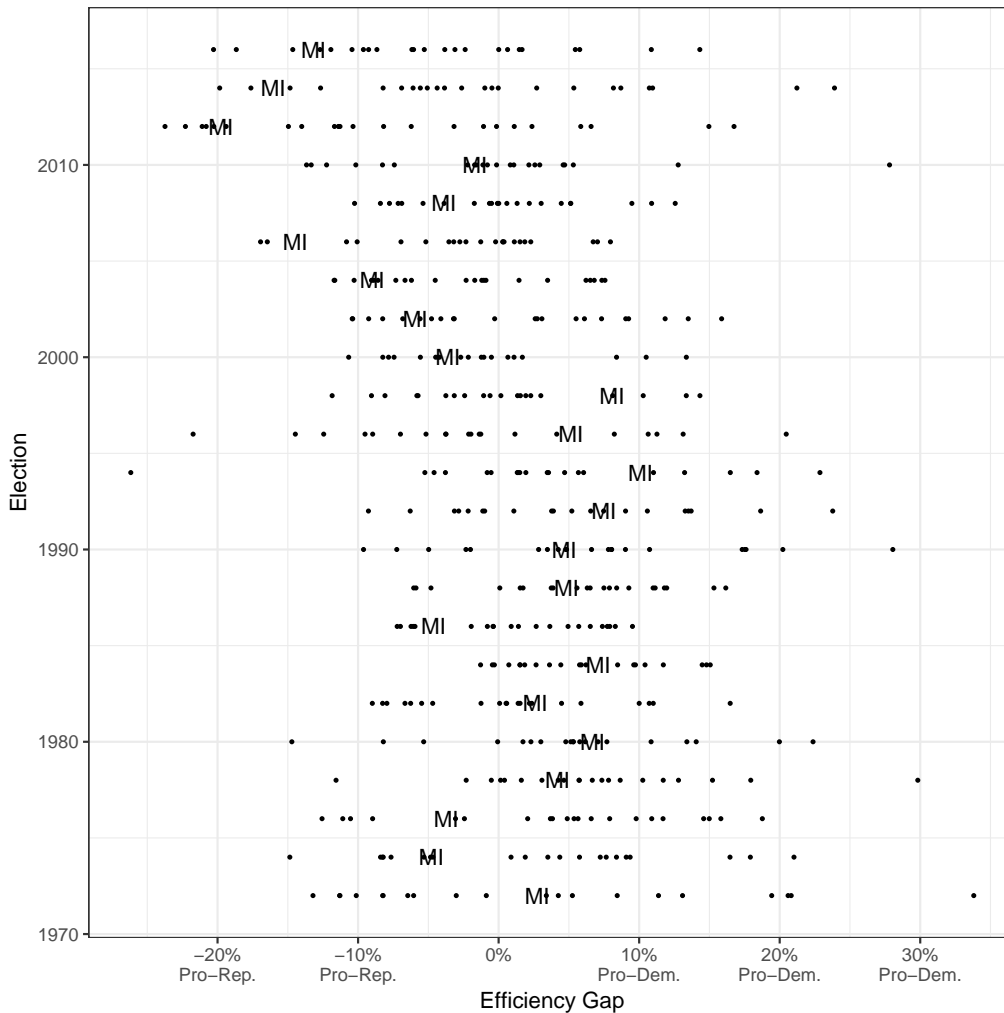


Figure 6: Efficiency Gap in Michigan Relative to Other States. The dots represent the Efficiency Gaps in individual states. The Efficiency Gaps in Michigan are labelled to distinguish them from other states.

Figure 6 compares the Efficiency Gap in Michigan to other states. Each dot in the chart represent a particular state's efficiency gap for congressional elections in that state that year. The chart shows that the Efficiency Gap in Michigan was generally similar to that of other states until the most recent redistricting. However, recent Efficiency

Gaps in Michigan are extreme relative to both its own historical Efficiency Gaps, and the Efficiency Gap in other states. After the most recent redistricting, Michigan had more extreme pro-Republican Efficiency Gaps than it has ever had before. This further suggests that geographic factors are unlikely to be the root cause of the large Efficiency Gap in Michigan in recent elections.

As a robustness check, I re-examined my analysis using estimates of the Efficiency Gap from three other sources that account for uncontested districts in slightly different ways. I obtain very similar results using each of these alternative Efficiency Gap measures.¹⁸

In sum, Michigan's 2011 congressional redistricting plan had one of the largest partisan biases of any congressional districting plan in history. The 2012 Efficiency Gap in Michigan was more extreme than 95% of previous plans in states with more than six seats over the past 45 years, and it was more Republican-leaning than 98% of previous congressional districting plans.

5.2 Other Measures of Partisan Bias in Michigan's Congressional Districts

Other measures of gerrymandering show a similarly large pro-Republican bias in Michigan's congressional districting plan.

- **Mean-Median Difference:** As we saw in section 4.2, the mean-median difference is an alternative approach for measuring partisan bias in a districting plan (Krasno et al., forthcoming; Best et al. 2017). This approach indicates that Michigan's 2012 plan had a gap between the mean and median district of 6.9%. This was more extreme than the mean-median difference in 78% of previous elections and more pro-Republican than the mean-median difference in 89% of previous elections.
- **Declination:** The declination metric is another alternative approach for measuring partisan bias in a districting plan (Warrington 2018). This approach arguably captures partisan intent better than other techniques (McGhee 2018). The declination approach too shows the extremity of Michigan's recent plans. In fact, Michigan's

18. First, the Efficiency Gap measure using the simpler assumption that the winner in uncontested races receives 75% of the vote and the loser receives 25% of the vote also indicates that Michigan had the fifth largest Efficiency Gap in the country in 2012 and the third worst across the 2012-16 elections. Second, the Efficiency Gap estimates produced by the Public Policy Institute of California also indicate that Michigan had the sixth largest Efficiency Gap in the country in 2012 and the fourth worst across the 2012-16 elections. Third, the Brennan Center's Efficiency Gap estimates indicate that Michigan had the sixth largest Efficiency Gap in the country both in 2012 and fourth largest across the 2012-16 elections. Finally, an estimate of the Efficiency Gap using presidential election results indicates that Michigan had the fifth most pro-Republican Efficiency Gap in 2012.

2012 election had a declination score of -0.56.¹⁹ This was more extreme than 91% of previous elections and more pro-Republican than 96% of previous U.S. congressional elections over the past 45 years.

5.3 Partisan Gerrymandering & Representation in Congress

In the previous sections, I have shown that Michigan’s 2011 current districting plans led to a substantial and durable partisan advantage for Republicans. Moreover, this partisan bias is large both relative to other states and relative to previous districting plans in Michigan. Now, I turn to the effects of this partisan advantage for the representation that Michigan’s citizens receive in Congress. The growing pro-Republican Efficiency Gap diminishes the ability of Democratic voters in Michigan to elect representatives of their choice. The growing polarization in Congress means that representatives in Congress nearly always vote the party line. So Democrats whose votes are wasted due to gerrymandering do not have their views represented in Congress. This means that they have little, if any, voice on important issues. Thus, the combination of partisan gerrymandering and polarization in Congress has a profound, pernicious effect on democratic representation.

5.3.1 Growth of Polarization in Congress

It has been widely documented that partisan polarization in Congress has grown significantly in recent decades. This work has shown that congressional voting is increasingly polarized by party. Indeed, the gap between the roll call behavior of the two parties has grown substantially since the 1970s (Poole and Rosenthal 1997; McCarty, Poole, and Rosenthal 2006, 2009; Bartels, Clinton, and Geer 2016).²⁰ The responsiveness of legislators to district preferences has also waned during this period. In recent years, there has been “muted responsiveness to localities” (Ansolabehere, Snyder, and Stewart 2001).

In this section, I first use a variety of methods to document the growing polarization in Congress. I also show that the gap between the parties has grown in Michigan just as it has in the nation as a whole. One simple approach to showing the growth in polarization is to examine changes in the proportion of the time that members of each party vote in a conservative direction on individual roll calls. Recent work by Professors Anthony Fowler and Andrew Hall has classified whether each roll call vote is liberal or conservative, and

19. It is worth noting that this score, which is based on my own analysis, is identical to the one presented in Warrington (2018).

20. It is important to note that there is no evidence using pre-2011 redistricting data that gerrymandering causes this polarization (McCarty, Poole, and Rosenthal 2009). There is not yet a consensus about the effect of redistricting on polarization in recent years. Regardless of whether gerrymandering causes polarization, however, polarization exacerbates the effects of gerrymandering on the political process.

the percentage of the time that each member of congress votes in a conservative direction relative to the median legislator (Fowler and Hall 2017).

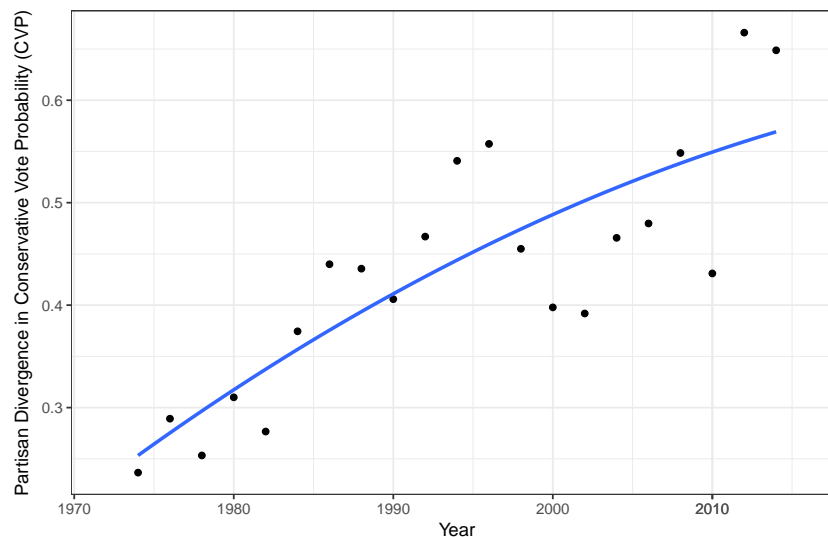


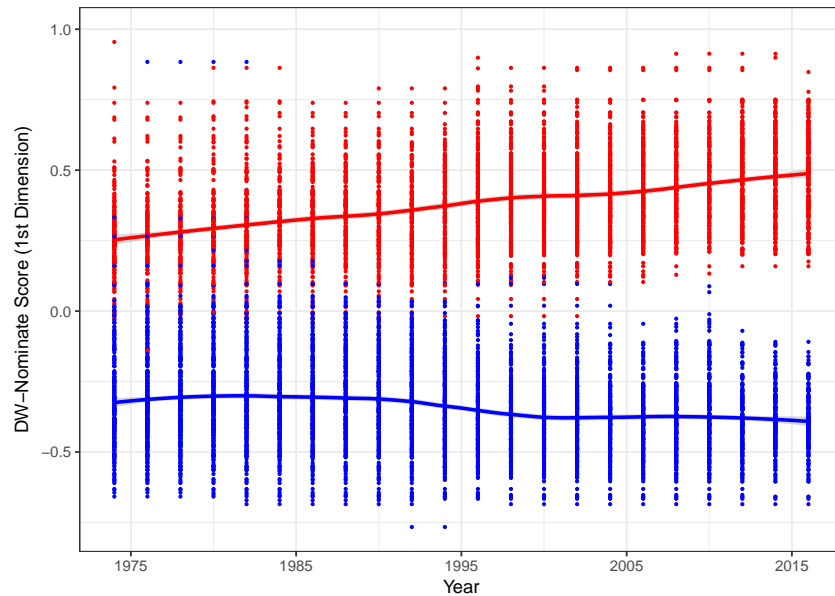
Figure 7: Difference in the Proportion of the Time that Members of Each Party Vote Conservatively. The dots represents the averages in each year, and the line shows a moving average.

Figure 7 above shows the difference in the proportion of votes that members of each party vote in a conservative direction. It shows that the gap between the parties grew substantially in the late 1980s and early 1990s, and then again in 2012. In the most recent Congress where data is available (113th), there was a 65% difference between Democrats and Republicans.

A limitation of this analysis, however, is that it implicitly treats all “conservative” roll calls as equally conservative. Imagine that conservative roll calls today would enact more conservative policies than conservative roll calls in the 1980s. In this case, it might be reasonable for a moderate congressperson, who is equally conservative in both periods, to vote for the conservative position in the 1980s and against it today. Thus, the estimates of conservative vote probabilities are not comparable inter-temporally either for individual members or for Congress as a whole.

To address this issue, Political Scientists have developed a number of different ways to estimate the latent ideology of members of Congress based on their roll call votes (for a review, see McCarty 2011). In this section, I’ll focus on the most prevalent model – the DW-Nominate scores developed by Professors Howard Rosenthal and Keith Poole (Poole and Rosenthal 1997). These scores are considered the classic, established estimates of the ideology of members of Congress. They have been used by hundreds of political science studies.

(a) Average Ideology of Democrats and Republicans in the U.S. House



(b) Partisan Polarization in the U.S. House

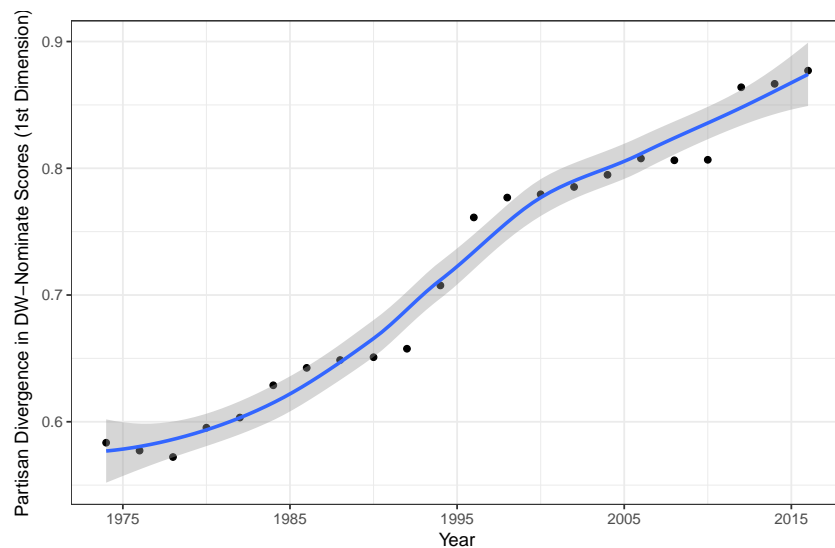


Figure 8: Polarization in Congress: The top panel shows the average ideology of members of each party in the U.S. House. The bottom panel shows the growth in polarization between members of the two parties in the U.S. House.

These scores characterize legislators' latent ideology using a statistical model based on all of their roll call votes.²¹ The score for each member ranges from -1 (most liberal) to +1 (most conservative). These ideology scores are made inter-temporally comparable

21. Poole and Rosenthal (1997) show that a single dimension is sufficient to summarize congressional voting behavior quite accurately for most of the history of the United States.

based on the assumption that individual members of Congress keep the same ideological position throughout their career in Congress.²²

The top panel of Figure 8 (above) shows the trends in the average ideology of Democrats and Republicans in the United States House over the past forty years. It shows the DW-Nominate scores of each member of Congress, as well as the average for each party. It illustrates that there is no overlap at all in today's Congress between the ideologies of Democrats and Republicans. In other words, Republicans are *always* substantially more conservative than Democrats in Congress. The bottom panel of Figure 8 shows the gap between the parties. It indicates that the gap between Democrats and Republicans has been steadily growing for the past few decades. However, polarization has increased substantially in recent years.

5.3.2 Growth of Polarization among Michigan's Members

Polarization has also grown significantly among Michigan's representatives in the U.S. House. Figure 9 shows the growth in polarization between Democratic and Republican members of the House from Michigan over the past forty years. The top panel of Figure 9 shows the ideology scores of each member of Congress, as well as the average for each party.

The figure illustrates that there has never been any overlap in Congress between the ideology scores of Democrats and Republicans from Michigan. Republicans are *always* substantially more conservative than Democrats from Michigan. The bottom panel of Figure 9 (below) shows the gap between the parties. Just like in the Congress as a whole, it indicates that the gap between Democrats and Republicans has been steadily growing in recent decades. These trends in Michigan are consistent with findings at the national level on the increasing polarization of voting in Congress (Poole and Rosenthal 1997) and the nationalization of voting patterns in elections (Hopkins 2018).

22. Poole and Rosenthal also estimated DW-Nominate scores that assume that each legislator's ideology can only change over time in a parametrically specified manner which generally rules out dramatic shifts in the ideology of individual legislators from one Congress to the next (see Bartels, Clinton, and Geer 2016). These scores show even larger increases in polarization than the scores that assume individual members of Congress keep the same ideological position. However, due to their more transparent assumptions and the fact that they yield more conservative estimates (in the nonpolitical sense of conservative) of the growth in polarization, I use the DW-Nominate scores that assume individual members of Congress keep the same ideological position throughout the analyses that follow.

(a) Average Ideology of Dem.'s and Rep's among Michigan Representatives (b) Partisan Polarization between Dems. and Reps. in Michigan

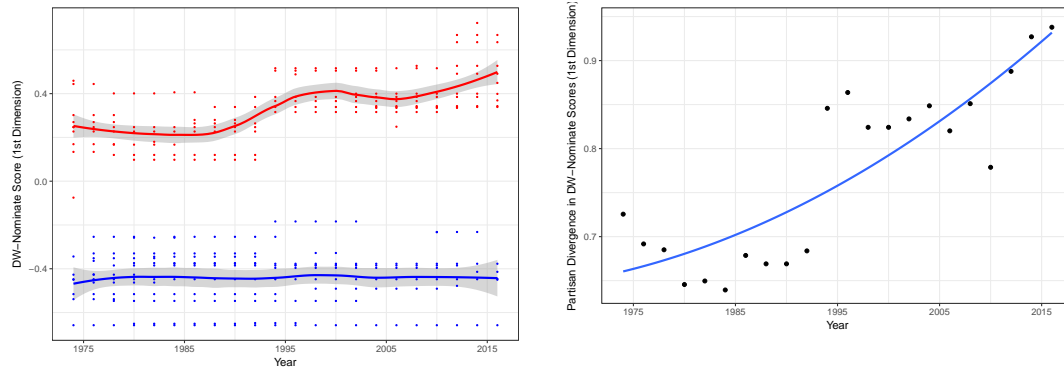


Figure 9: Polarization among Michigan representatives: The left panel shows the average ideology of members of each party in Michigan. The right panel shows the growth in polarization between members of the two parties in Michigan

5.3.3 The Efficiency Gap and Roll Call Voting in Congress

In this section, I examine the effect of the Efficiency Gap on roll call voting patterns in Congress. I show that a more pro-Republican Efficiency Gap leads to more conservative roll call voting. To be clear, I do not argue that gerrymandering causes more polarization in Congress. Rather, building upon previous work on both state legislatures (Caughey, Tausanovitch, and Warshaw 2017) and Congress (Stephanopoulos 2018), I show that pro-Republican changes in the Efficiency Gap leads to more conservative roll call voting in Congress because (1) more pro-Republican Efficiency Gaps lead to more Republicans taking office (see Section 4) and (2) more Republican seats leads to more conservative roll call voting patterns (and increasingly so in recent years, as Republicans have gotten more conservative over time, as shown in Section 5.3.1).

The details of my results are found in Table 3 (below).²³ The key finding is that changes in the Efficiency Gap have a strong and robust relationship with roll call voting behavior. Across the entire time period, a 10% pro-Republican shift in the Efficiency Gap is associated with a .07 shift to the right in legislators' ideology (i.e., DW-Nominate scores). Moreover, due to the growing polarization in Congress, the effect of the Efficiency Gap on legislators' average ideology has grown substantially in recent years. The right column shows that in the most recent Congresses, a 10% pro-Republican shift in the Efficiency Gap is associated with a .09 shift to the right in DW-Nominate scores. This

23. I use a model with fixed effects for state and year. This model is the workhorse model for causal inference in economics and political science (Angrist and Pischke 2009). The state fixed effects account for time-invariant confounders in each state and the year fixed effects account for shocks that affect all states equally.

Table 3: Effect of Efficiency Gap on Average Legislator Ideology in Each State

	<i>Dependent variable: Ave. Ideology of Legislators in Each State</i>	
	(1)	(2)
Efficiency Gap	−0.0073*** (0.0004)	
EG (1970s)		−0.0068*** (0.0007)
EG (1980s)		−0.0047*** (0.0009)
EG (1990s)		−0.0075*** (0.0008)
EG (2000s)		−0.0073*** (0.0009)
EG (2010s)		−0.0093*** (0.0009)
State Fixed Effects	X	X
Year Fixed Effects	X	X
Observations	508	508
R ²	0.880	0.884
<i>Note:</i>		*p<0.1; **p<0.05; ***p<0.01

is roughly equivalent to the difference between the ideologies of Republican Senators John Cornyn and Lindsey Graham. Cornyn was rated as the second most conservative senator by the nonpartisan National Journal in 2011-12 (FactCheck.org 2013) and is one of the Senators most likely to support President Trump (FiveThirtyEight.com 2017). In contrast, Graham often takes moderate positions. For instance, he nearly co-sponsored legislation to address climate change (Lizza 2010) and he is one of the Republicans least likely to support Trump's positions in the most recent congress (FiveThirtyEight.com 2017).

5.3.4 The Efficiency Gap & Representation in Affordable Care Act Repeal

In this section, I show how gerrymandering can impact representation. Specifically, I show that citizens are much more likely to agree with the roll call votes of same-party legislators than opposite party legislators on important policy issues. Moreover, people whose votes

are artificially wasted due to gerrymandering are deprived of having legislators that agree with their views. As a result, gerrymandering can be responsible for voters effectively having no political voice in Congress.

For this analysis, I use data from the 2016 Cooperative Congressional Election Study (CCES) (Ansolabehere and Schaffner 2017).²⁴ This is a large-scale study about how Americans view Congress and hold their representatives accountable during elections, how they voted and their electoral experiences, and how their behavior and experiences vary with political geography and social context.²⁵ The large sample is capable of capturing variation across a wide variety of legislative constituencies. In fact, the state-level samples are large enough to measure with a reasonable degree of precision the distribution of voters' preferences within most states.

First, I examine how much it matters whether citizens and legislators share the same political party. I focus on the vote to repeal the Affordable Care Act ("ACA") in February 2015 since the ACA is probably the seminal political issue of the past decade.²⁶ On this issue, about 22% of Democrats in Michigan favored the repeal in a the 2014 CCES, while more than 89% of Republicans favored it. Congress split even more starkly – all of the Republicans in the House from Michigan voted for the repeal and all of the Democrats voted against it. The division between Democrats and Republicans in Congress on the Affordable Care Act is a microcosm of the polarization in Congress that I discussed in the previous section.

The CCES data indicate that voters are much more likely to agree on the ACA repeal with the position of members of their party than legislators from the opposite party. Democrats in Michigan agreed with Democratic legislators' roll call votes about 70 percent of the time on the repeal vote. In contrast, they only agreed with Republican legislators' roll call votes about 20 percent of the time. This implies that Democrats were 50 percentage points more likely to agree with Democratic than Republican legislators on this issue. The data indicates even stronger results for Republican citizens. They were about 84 percentage points more likely to agree with Republican than Democratic legislators. Averaging across both parties, citizens from Michigan were about 65 percentage points more likely to agree with a legislator of the same party on the repeal vote than one of the opposite party. I find similar patterns in the nation as a whole. Across the entire

24. I use this survey because it has already matched legislators' roll call votes in February 2015 with constituent opinions. However, there was no major shift in public opinion on the ACA during this period, so I would expect similar results using other surveys from 2014-16.

25. The survey was conducted through the Internet by YouGov of Redwood City, CA.

26. The roll call is on H.R. 596, a bill "to repeal the Patient Protection and Affordable Care Act and health care-related provisions in the Health Care and Education Reconciliation Act of 2010, and for other purposes."

nation, Americans were about 56 percentage points more likely to agree with a legislator of the same party than one of the opposite party on the vote to repeal the Affordable Care Act. This shows that voters are extremely unlikely to see their preferences on major bills translated into action in Congress when their legislator is from the opposite party.

Next, I examine whether the congruence between the views of citizens and the actions of legislators on the repeal of the Affordable Care Act is lower in states where people's votes are more likely to be wasted. I estimate the weighted proportion of Democrats, Independents, and Republicans within each state whose views are congruent with the views of their legislator on the repeal of the Affordable Care Act.”²⁷

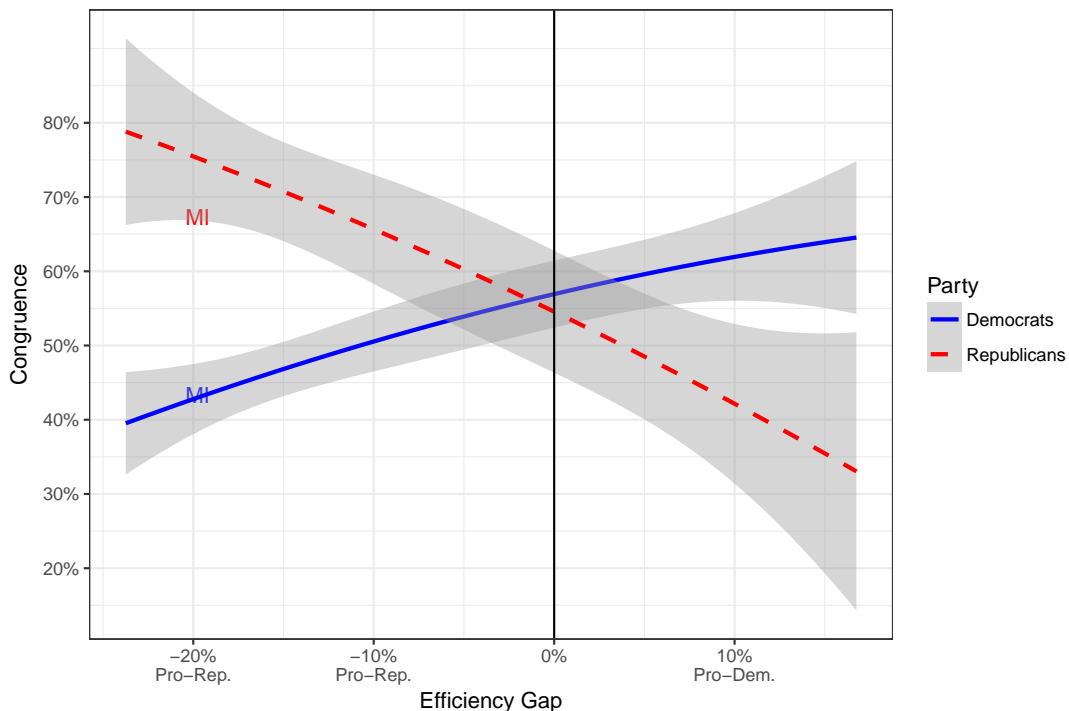


Figure 10: Association Between Efficiency Gap and the Congruence Between Public Opinion and Legislators' ACA Repeal Vote

Figure 10 shows that there is a strong association between the Efficiency Gap and the percentage of Democrats and Republicans in each state whose views on the repeal of the Affordable Care Act are congruent with the positions of their legislators. Democratic citizens and their legislators were about a third less likely to agree with each other in states with a large pro-Republican Efficiency Gap as in states with no Efficiency Gap. Likewise, Republicans were much less likely to agree with their legislators in states with a large pro-Democratic Efficiency Gap than in states with no Efficiency Gap. Finally,

27. I treated Independents that leaned toward a party as partisans for this analysis.

the graph shows that Democrats and Republicans are roughly equally likely to agree with their member of Congress on the Affordable Care Act in states with no Efficiency Gap.

Figure 10 also shows that Democrats in Michigan were much less likely to agree with their legislators on the Affordable Care Act repeal vote than Republicans were. About 67% of Michigan Republicans agree with their representative on the Affordable Care Act repeal, while only about 43% of Democrats agree with their representative. This is not surprising since Michigan Democrats were much more likely than Republicans to have their votes wasted.

Overall, the analysis in this section suggests that partisan gerrymandering has a large effect on representation. That is, it has a substantial effect on the congruence between citizens' views and legislators' roll call votes on important policy issues. Citizens whose votes are wasted have little, if any, voice in Congress on the Affordable Care Act, and other important issues.

5.3.5 Partisan Gerrymandering and Citizens' Trust in their Representatives

In the previous sections, I showed that the Efficiency Gap has an important effect on roll call voting patterns in Congress. It also affects citizens' representation in Congress. Citizens whose votes are wasted in states with large Efficiency Gaps are less likely to see their preferences translated into policy. Here, I show that citizens whose votes are wasted due to partisan gerrymandering also have less faith in their elected officials. Specifically, I show that citizens in states with large Efficiency Gaps have less trust in their representatives in Congress than citizens in states with smaller Efficiency Gaps. This suggests that partisan gerrymandering not only distorts the link between elections and the legislature, it undermines Americans' faith in democracy itself.

For this analysis, I use data from the 2014 Cooperative Congressional Election Study (Ansolabehere and Schaffner 2015).²⁸ I estimate the weighted proportion of people within each state that "trust your district's Representative in Congress to do what is right." In general, many people lacked trust in their Representative. Only about 30% of the people in each party indicate that they trusted their Representative to do what's right.

Figure 11 examines whether citizens' trust for their representatives is lower in states where votes are more likely to be wasted. The graph shows that the answer is clearly yes. Citizens are about 25% less likely to believe that their Representative will do what is right in states with a large pro-Republican Efficiency Gap than in states with no Efficiency Gap. The graph also shows the average levels of citizens' trust for their representatives

28. The survey was conducted through the Internet by YouGov of Redwood City, CA.

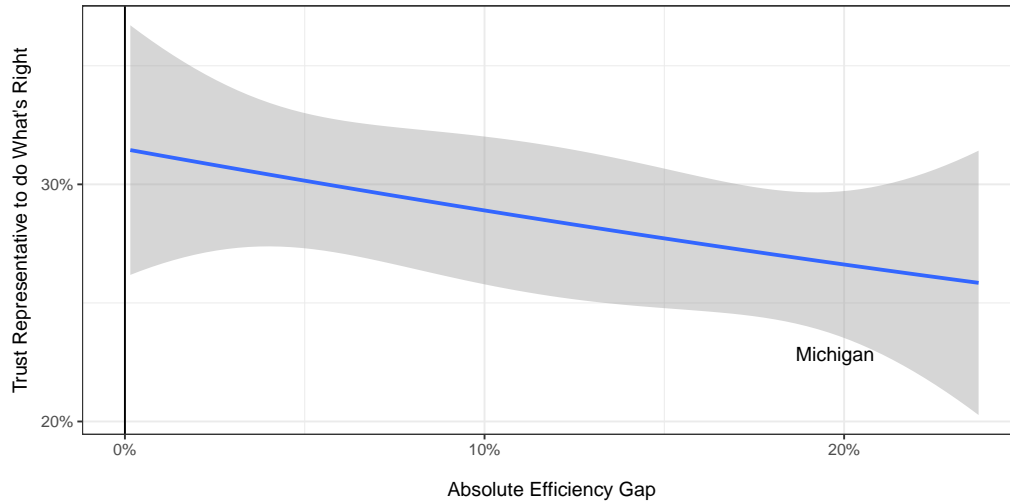


Figure 11: Association Between Efficiency Gap and Citizens' Trust in their Representative

in Michigan. Only about 23% of Michigan residents trust their representatives, which is one of the lowest of any state in the country.

Overall, this analysis indicates that bias in the districting process has large and profound effects on citizens' trust in their representatives in Washington DC. When voters lose the ability to elect representatives of their party as a result of gerrymandering, this undermines their faith in their representatives. This suggests that gerrymandering impacts not just the representatives we select and their roll call votes in Congress, but citizens' faith in democracy itself.

6 Gerrymandering in State Legislative Districts

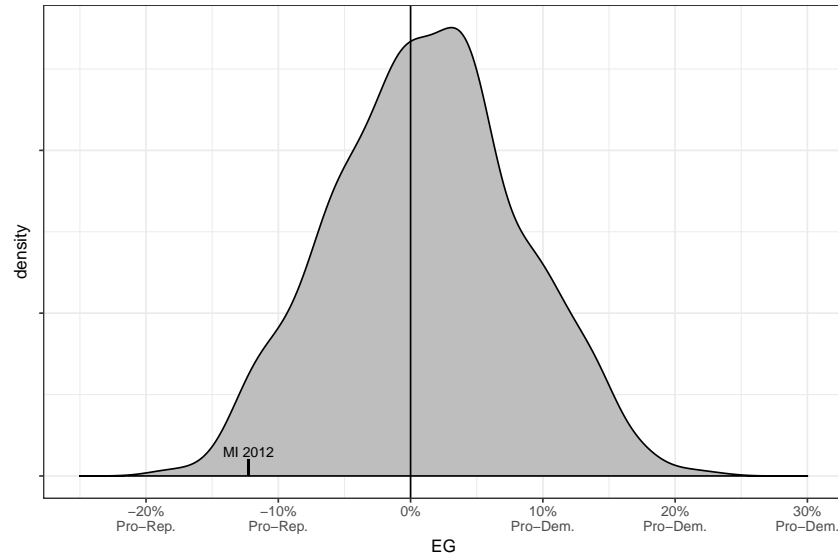
In this section, I will first provide an historical overview of the Efficiency Gap in state legislative districts over the past 45 years. Then, I will show that Michigan's 2011 redistricting plan is historically extreme compared to both other states and its own plans in previous decades. Finally, I will show that partisan bias in state legislative districts has important consequences for the political process in state government.

6.1 Efficiency Gap in State Legislatures

First, I analyze the historical trajectory of the Efficiency Gap in Michigan's state legislature. Figure 12 shows the distribution of Efficiency Gaps between 1972 and 2016 in both the lower and upper chambers of state legislatures. The plots here indicate the relative proportion of states with different values of the Efficiency Gap. The Efficiency Gap in

most state-election years are represented in the distribution.²⁹ Michigan's first post-2011 Efficiency Gaps are shown on the bottom-left of each plot.

(a) Lower State Legislative Chambers



(b) Upper State Legislative Chambers

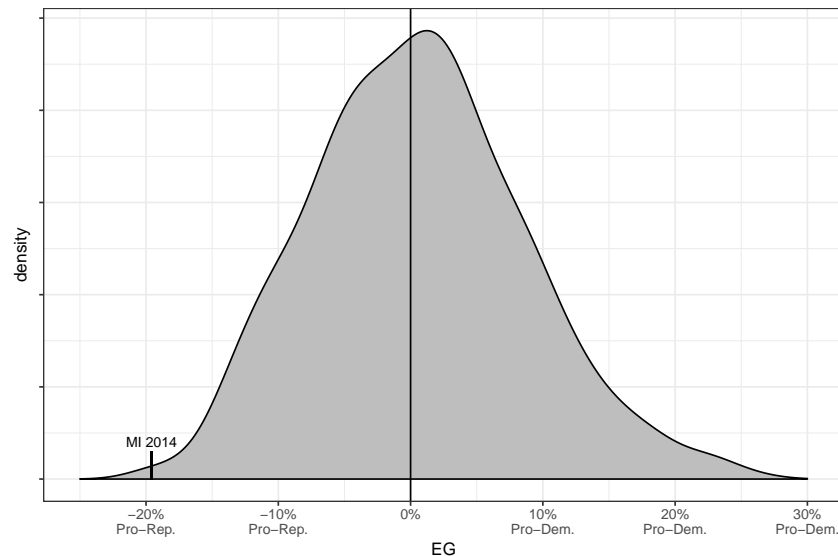


Figure 12: National Distribution of Efficiency Gaps in State Legislative Lower and Upper Chambers: 1972-2016.

These plots illustrate several important facts. First, they indicate that over this entire period the average state had a slightly Democratic leaning Efficiency Gap in both lower

29. As discussed in the appendix, I drop state-years that cannot be matched to presidential voting information or that predate a mid-decade redistricting. I also drop the first upper chamber elections after a decennial redistricting since these often use districts that were drawn pre-redistricting.

(state houses) and upper (state senates) chambers.³⁰ Second, they indicate that the bulk of Efficiency Gaps are small. In fact, roughly 84% of Efficiency Gap in lower chamber plans lie between -10% and 10%. Only about 4% of state-level Efficiency Gap have more than a 20% advantage for either party. Finally, the plots show that the Efficiency Gap in Michigan's first elections after the 2011 plan went into place were historically extreme.

6.1.1 Historical Trajectory of the Efficiency Gap in State Legislatures

Next, I examine the historical trajectory of the Efficiency Gap in state legislatures between 1972 and 2016 (Figure 13). The vertical bars delineate changes in the decennial districting plans. The upper panel shows lower chambers and the lower panel shows upper chambers.

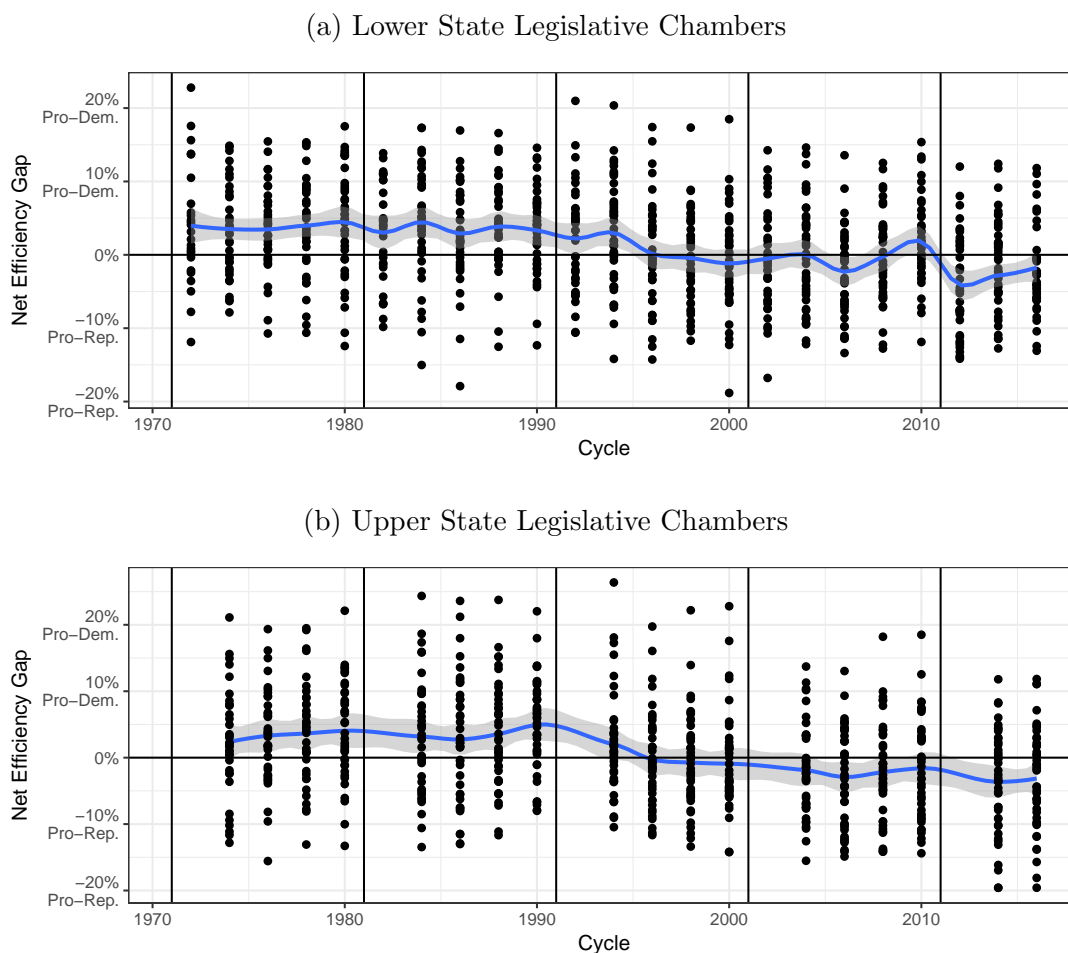


Figure 13: Historical Trajectory of the Efficiency Gap (EG). Each vertical line shows the demarcation between decennial redistricting plans. The line shows the moving average and the grey bar is a confidence interval. The dots show EGs in individual states.

30. Stephanopoulos and McGhee (2015, 870) reach similar findings.

Similarly to Congress, the plot indicates that the average Efficiency Gap in state legislatures was slightly Democratic leaning in the 1970s and 1980s. This advantage dissipated though by the end of the 1980s. In the 1990s, neither party had a significant net-advantage in the Efficiency Gap. In the first half of the 2000s, Republicans developed a very small advantage in both lower and upper chambers of state legislatures (see also Stephanopoulos and McGhee 2015). However, the average advantage of Republicans across all states was still modest in recent years. For instance, it only about 3% in 2012.

6.1.2 Partisan Control of the Redistricting Process and the Efficiency Gap

Of course, the Efficiency Gap in state legislatures can be non-zero and differ across states for reasons unrelated to the drawing of district lines, such as variation in how different demographic groups are distributed across geographic space (Chen and Rodden 2013). As we saw earlier, however, there is a wide body of evidence from previous political science studies that control of the redistricting process influences the partisan balance in subsequent elections (Niemi and Jackman 1991; Gelman and King 1994b; McGhee 2014; Stephanopoulos 2018). These studies strongly suggest that political control of redistricting continues to have large and durable effects, which are at least partially captured through changes in the Efficiency Gap.

6.1.3 Durability of the Efficiency Gap in State Legislatures

Next, I examine the durability of the Efficiency Gap. Put differently, how well does the Efficiency Gap immediately after the decennial redistricting predict subsequent Efficiency Gaps? Figure 14 (below) shows that the Efficiency Gaps in state legislative lower chambers stemming from the 2011 redistricting have been quite durable (though somewhat less durable than congressional plans).

Overall, there is a 0.68 correlation nationwide between the Efficiency Gaps in 2012 and the Efficiency Gaps four years later in 2016. Moreover, Michigan's Efficiency Gap in 2016 was similar to its Efficiency Gap in 2012. This analysis shows that recent Efficiency Gaps are durable, and thus partisan gerrymandering in state legislatures is unlikely to be remedied through the normal electoral process.

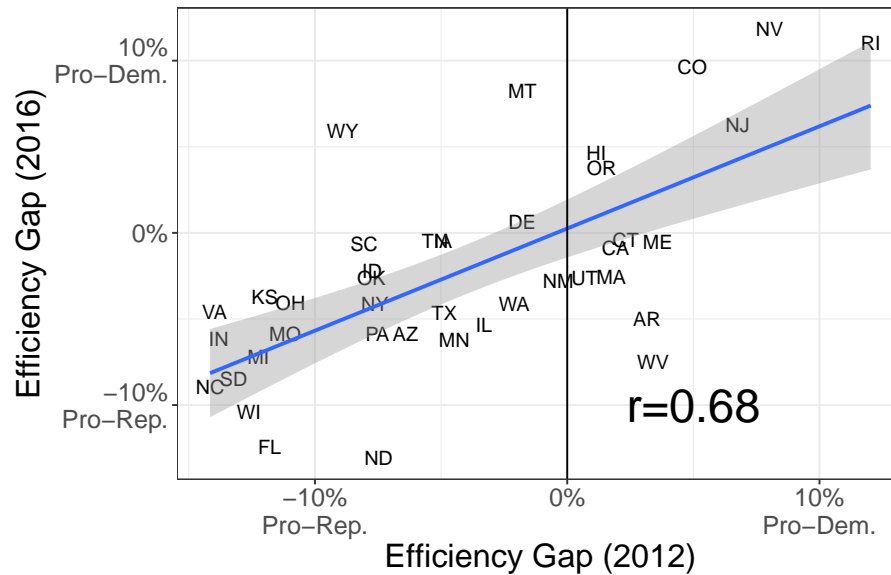


Figure 14: Durability of Efficiency Gap. This graph compares Efficiency Gaps in 2012 and 2016. It shows that recent Efficiency Gaps are quite durable.

6.1.4 Efficiency Gap in Michigan's State Legislature

The previous section showed trends in the nationwide trajectory of the Efficiency Gap in state legislative districts. In this section, I focus on the Efficiency Gap in Michigan's state house and senate. In recent elections, Michigan has had a pro-Republican Efficiency Gap that is extreme relative to both its own historical Efficiency Gaps, and the Efficiency Gap in other states. Just as in Congress, the Efficiency Gaps in Michigan's state legislative districts, and especially in its state senate, in the past three elections were among the most Republican-leaning Efficiency Gaps the nation has ever seen.

Figure 15 shows trends in the Efficiency Gap in Michigan between 1972 and 2016. It indicates that the 2011 redistricting plan led to a large Republican advantage in Michigan state legislative elections unlike what the state experienced after previous redistricting periods. In the 1970s-1990s, Michigan had very neutral Efficiency Gaps with few clear advantages for either party. In the 2000s, Republicans gained an advantage, likely in part due to their control of the redistricting process in 2001 (Stephanopoulos 2018).

Michigan's state legislative map developed a larger pro-Republican Efficiency Gap after the 2011 redistricting. In 2014, for example, Democrats received about 49% of the votes in the state senate election (after accounting for uncontested seats) and only 29% of the seats.³¹ This yielded a huge pro-Republican Efficiency Gap of almost -20%, one of the

31. I drop the first state senate elections after a decennial redistricting since many states, including Michigan, used districts that were drawn pre-districting. So I focus on the 2014 elections here since those were the first ones held using entirely post-redistricting districts.

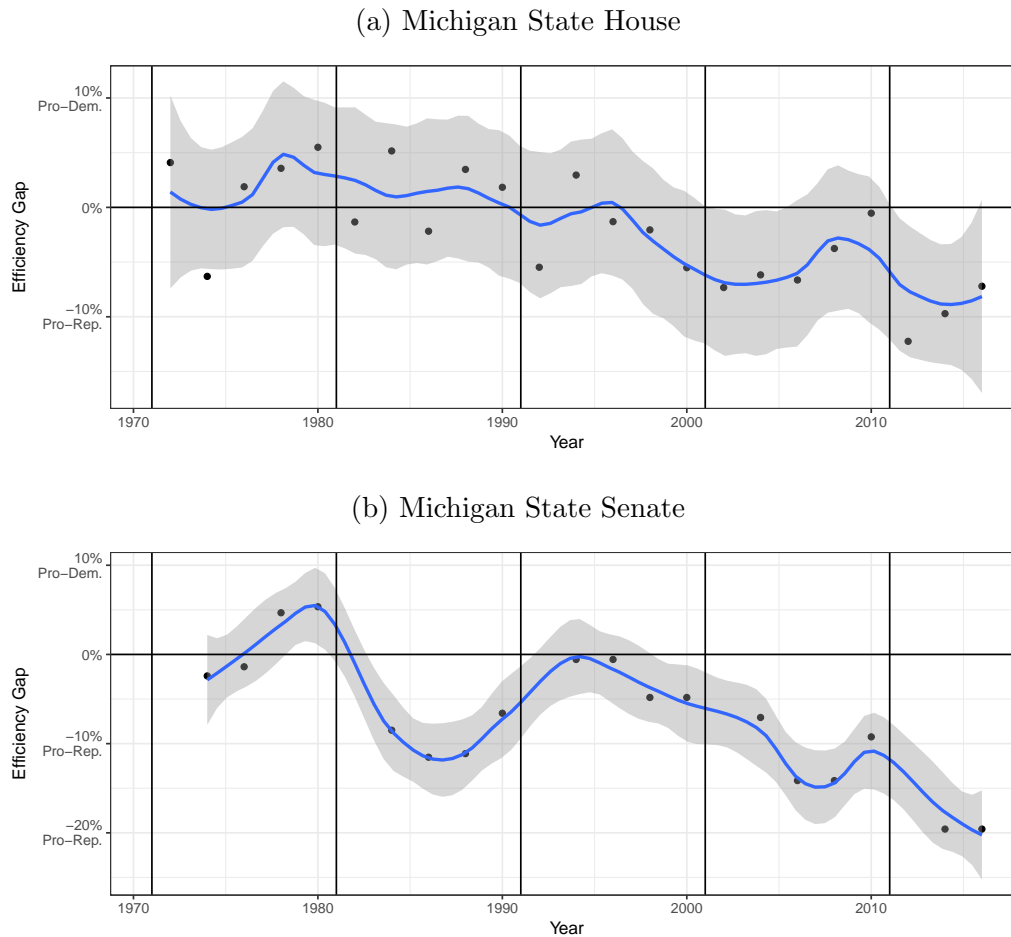


Figure 15: Historical Trajectory of the Efficiency Gap in Michigan. Each vertical line shows the demarcation between decennial redistricting plans. The blue line shows the moving average and the grey bar is a confidence interval. The dots represent the Efficiency Gaps in each year in Michigan.

largest in history. In the state house elections in 2012, Democratic candidates won 54% of the statewide vote, but they won only 46% of Michigan’s state house seats. This led to a pro-Republican Efficiency Gap of approximately -12.3%.³² The results in the next two state house elections were similar to those in 2012.

Figure 16 compares the Efficiency Gap in Michigan to other states. Each dot in the chart represent a particular state’s efficiency gap for state house and state senate elections in that state that year. The chart shows that the Efficiency Gap in Michigan was generally similar to that of other states until the most recent redistricting. However, recent Efficiency Gaps in Michigan’s state legislative districts are extreme relative to both

32. These results are slightly different from alternative Efficiency Gap estimates that do not adjust for differences in turnout across districts. Indeed, if I had not adjusted for turnout differences, I would find an Efficiency Gap of 14.4% in Michigan in 2012.

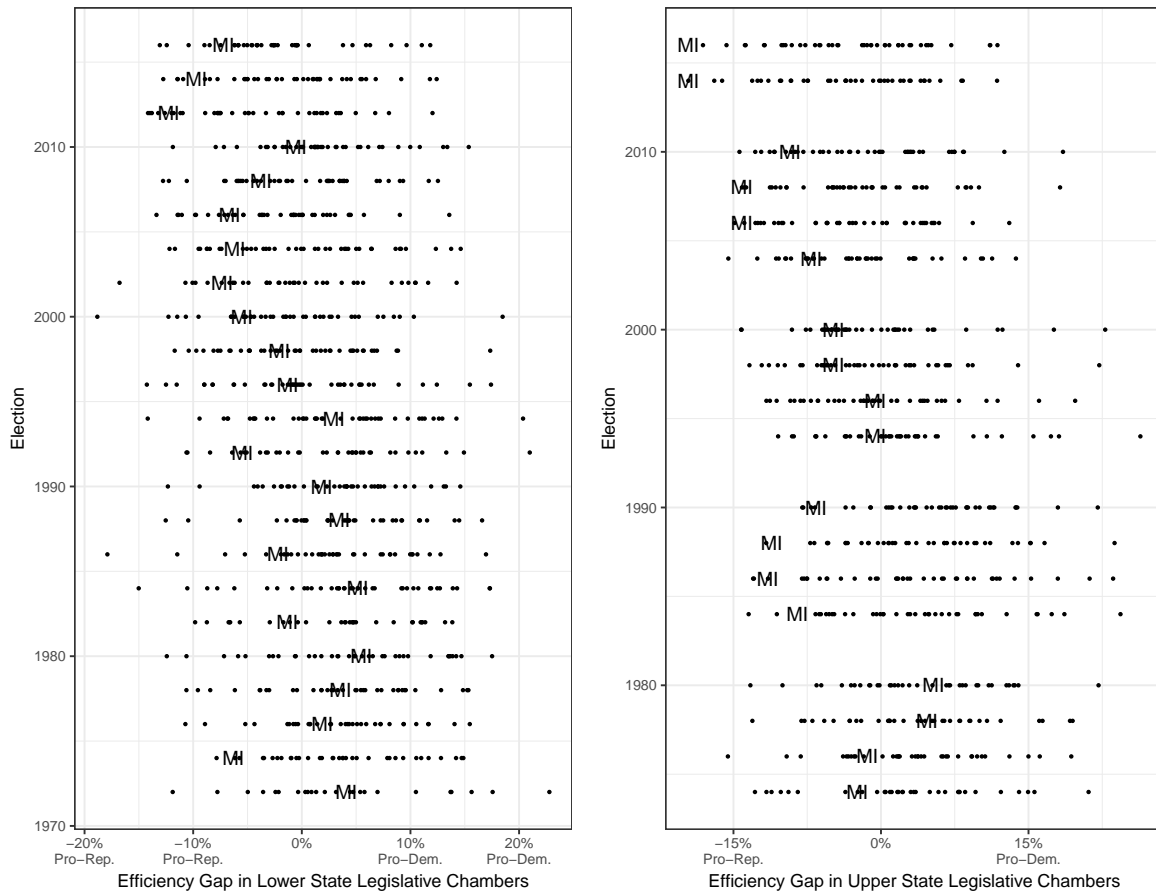


Figure 16: Efficiency Gap in Michigan Relative to Other States. The dots represent the Efficiency Gaps in individual states. The Efficiency Gaps in Michigan are labelled to distinguish them from other states.

its own historical Efficiency Gaps, and the Efficiency Gap in other states. After the most recent redistricting, Michigan's state legislative plans for both its state house and senate had far more extreme pro-Republican Efficiency Gaps than it has ever had before. This further suggests that geographic factors are unlikely to be the sole cause of the large Efficiency Gap in Michigan in recent elections. Finally, I re-examined my analysis using estimates of the Efficiency Gap from two other sources that account for uncontested districts in slightly different ways (Jackman 2015; Stephanopoulos and McGhee 2015). I obtain very similar results using each of these alternative Efficiency Gap measures.

In sum, the pro-Republican bias in Michigan's state legislative plans in the past three elections were among the most Republican-leaning Efficiency Gaps the nation has ever seen. Michigan's state house election in 2012 had a larger pro-Republican bias in its Efficiency Gap than 98% of the state house elections over the past five decades, and it had a larger absolute bias than 91% of previous plans. Turning to other metrics of

partisan bias in districting plans, it also had:

- A more extreme difference between the mean and median district than 97% of previous state house elections and a larger pro-Republican bias than in 98% of previous elections.
- A more extreme declination value than 90% of previous state house elections and a larger pro-Republican bias in its declination than 97% of the previous elections.

Likewise, Michigan's state senate results in the first election after its 2011 plan went into place in 2014 had a larger absolute Efficiency Gap than 98% of previous state senate elections, and it had a larger pro-Republican bias than 99.7% of the state senate elections over the past five decades. Using other metrics of partisan bias in districting plans, it also had:

- A more extreme difference between the mean and median district than 95% of previous state senate elections and also a larger pro-Republican bias in the difference between the mean and median district than 95% of previous elections.
- A more extreme declination value than 96% of previous state senate elections and a larger pro-Republican bias in its declination than 99% of the previous elections.

6.2 Partisan Gerrymandering & Representation in State Government

In the previous section, I have shown that Michigan's current districting plans have led to a substantial partisan advantage for Republicans in state legislative elections. Moreover, this partisan bias is large both relative to other states and relative to previous districting plans in Michigan. Now, I turn to the effects of this partisan advantage for the representation that citizens of Michigan receive in state government. The growing pro-Republican Efficiency Gap diminishes the ability of Democratic voters in Michigan to elect representatives of their choice. The polarization in state legislatures means that representatives in state legislatures nearly always vote the party line. So gerrymandering leads Democrats to be less likely to have their views represented in state government. This means that they have little, if any, voice on important issues in Michigan's state government.

6.2.1 Polarization in State Legislatures

Earlier, we saw that the Congress has become extremely polarized in recent years. In this section, we will examine polarization in state legislatures over the past two decades.

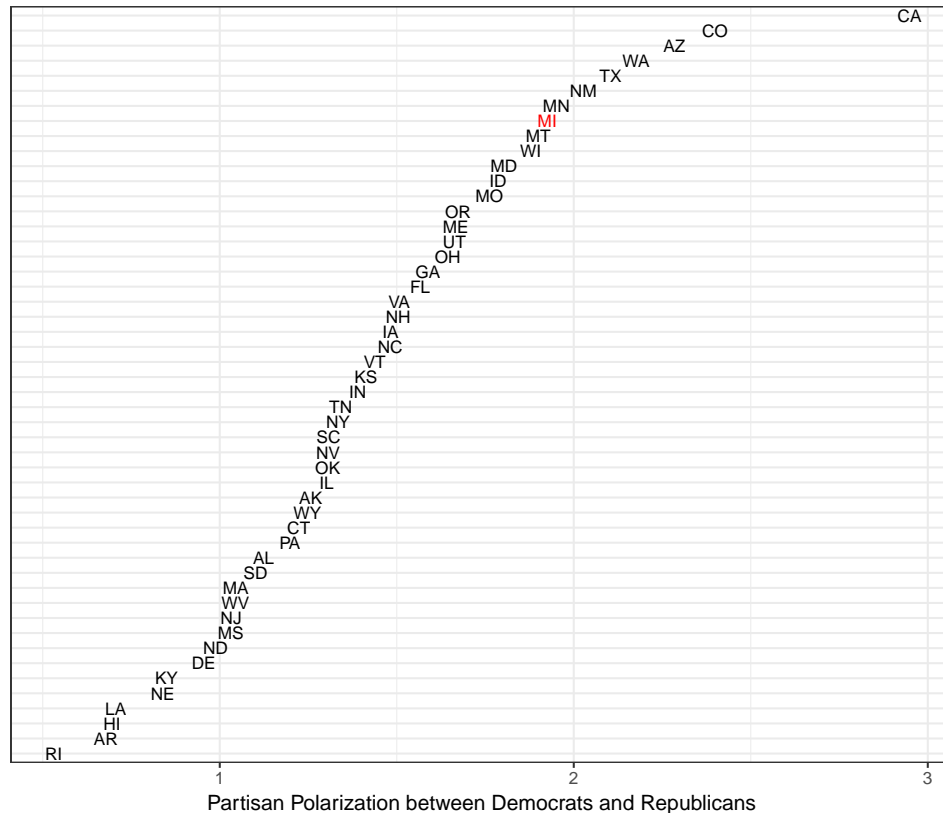


Figure 17: Polarization in Lower State Legislative Chambers in each State from 2001-2014.

Although an individual state legislator may cast hundreds or even thousands of roll call votes, their voting behavior can usually be parsimoniously summarized in terms of a single left-right score, their estimated ideology (Shor and McCarty 2011; compare Poole and Rosenthal 1997). Using roll-call records from all fifty state legislatures, Shor and McCarty (2011) have estimated the ideology of the members of every state legislature in each session between 1995 and 2014.³³ These estimated ideology scores summarize the ideological differences between different legislators, as expressed in their roll-call votes for and against legislative proposals.

Figure 17 (above) shows that state legislatures have become quite polarized in recent years. This chart shows the difference between the ideology scores of the median Democratic and Republican in each state's lower legislative chamber from 2001-2014. It indicates that the median Republican is over one standard deviation more conservative

33. Shor and McCarty (2011) use data from the National Political Awareness Test, a survey of legislators run by Project Vote Smart, in order to make comparisons between legislators across different states. Each legislator is assigned an ideology score based on all roll call votes using a statistical model that takes advantage of the similarities between the coalitions that emerge on different votes, rather than by subjective judgements of the individual votes.

than the median Democrat in most state legislatures. This is even true of legislators that represent similar, or even identical, constituencies (Shor and McCarty 2011; Fowler and Hall 2017; Caughey, Tausanovitch, and Warshaw 2017).

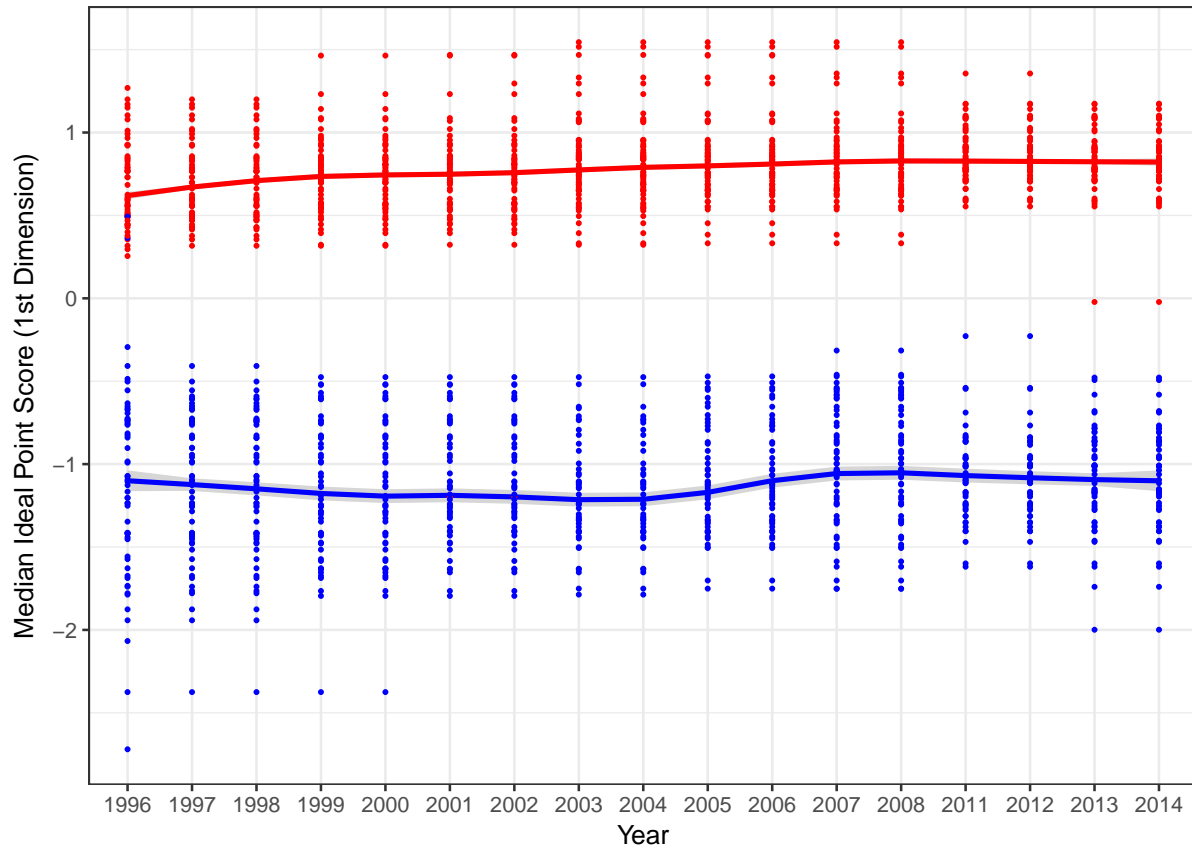


Figure 18: Average Ideology of Dem.'s and Rep.'s in Michigan State House

In Michigan, the median Republican is almost two standard deviations more conservative than the median Democrat. Figure 18 shows the average ideology of Democrats and Republicans in the Michigan state house over the past 20 years. It also shows the ideology of every individual member. This figure indicates that there is a large difference between the roll call voting patterns of Democrats and Republicans in Michigan. Moreover, Republican state legislators in Michigan are always more conservative than Democratic state legislators.

6.2.2 The Efficiency Gap and Roll Call Voting in State Legislatures

We know that partisan advantages in the efficiency gap give one party a larger seat share than they would have received without any advantage in the efficiency gap.³⁴ We also know that Republicans take much more conservative roll call positions than Democrats in state legislatures (Shor and McCarty 2011). Putting these facts together leads to the clear expectation that changes in the efficiency gap should lead to changes in the position of the median voter in state legislatures. But the magnitude of changes in the position of the median voter is not clear *a priori*. This depends on whether additional members of the majority party tend to be moderate (because they are winning closer districts) or typical for their party (when parties are polarized). As the seat share of the majority party grows, the median voter will be closer to the center of the majority party. At the same time, the center itself may be moving depending on the positions of the new members.

Table 4: The Effect of the Efficiency Gap on the Median Ideology in State Lower Chambers

	<i>Dependent variable:</i>	
	Median Ideology in State House	
	(1)	(2)
Efficiency Gap _{t-1}	-0.039*** (0.005)	-0.040*** (0.005)
Republican Presidential Share		0.032*** (0.007)
Lagged Outcome	0.374*** (0.054)	0.324*** (0.053)
Constant	0.805*** (0.191)	2.244*** (0.360)
Year FEs	X	X
State FEs	X	X
Lagged Outcome Variable	X	X
Observations	338	338
R ²	0.861	0.871
Adjusted R ²	0.833	0.845
<i>Note:</i> *p<0.1; **p<0.05; ***p<0.01		

In my published work, I have shown that a pro-Republican bias in the efficiency gap leads to more conservative median ideology scores of state legislators in lower chambers

34. This section is adapted from a peer-reviewed paper published in the *Election Law Journal* that I wrote with several co-authors (Caughey, Tausanovitch, and Warshaw 2017).

(Caughey, Tausanovitch, and Warshaw 2017). I reproduce that analysis here in Table 4 using the Efficiency Gap measures developed for this report and the ideology measures of state legislators developed by Shor and McCarty (2011).³⁵ The first column shows the results of a model that include fixed effects (FEs) for state as well as year and a lagged outcome variable. The second column adds a control for the results of most recent presidential election.³⁶ The estimates indicate that state-years in which the efficiency gap was more pro-Republican than average for that state also tended to have more conservative roll call voting behavior in the state house. Across both regression specifications, a one percentage point pro-Republican shift in the efficiency gap moves the median ideology scores in the state house 0.04 standard deviations to the right. These estimates suggest, for example, that the median ideology of the Michigan state house, which had a 12% pro-Republican efficiency gap in 2012, would shift nearly half a standard deviations to the left if it adopted a districting plan with no efficiency advantage for either party.

6.2.3 The Efficiency Gap and Policy Outputs in State Legislatures

Next, I examine the effect of the efficiency gap on state policy conservatism. In my published work, co-authors and I have shown that the partisan composition of state legislatures has an important effect on policy (Caughey, Warshaw, and Xu, Forthcoming).

Table 5 reproduces these results using regression specifications analogous to those in Table 4. It indicates that a one percentage point pro-Republican shift in the efficiency gap increases state policy conservatism by 0.003 standard deviations. This means that a 12 percentage point increase in the efficiency gap would increase policy conservatism by 0.036 standard deviations, which is equivalent to about a percentage point increase in the percentage of conservative policies in a state. This effect is similar to the effect of a shift of one percentage point in the composition of the vote for president (column 2) and is larger than the effect of a governor's partisanship.

35. Note that I obtain similar substantive findings using the mean-median and declination measures in this analysis as well as in the analysis in the next section on the effect of gerrymandering on state policy.

36. These specifications capture the relationship between the efficiency gap and legislative roll call voting patterns within states net of national trends, eliminating the influence of time-invariant state-specific confounders. It also includes a lagged outcome variable to control for states' recent policy history. In column (2), we add the Republican presidential vote in the previous presidential election. This controls for variation in the position of the median voter in the state. Not surprisingly, we find that states that are more Republican in presidential elections also have a more conservative state house. The effect of the efficiency gap, however, is essentially identical here to the model in column (2).

Table 5: The Effect of the Efficiency Gap on State Policy Conservatism, 1972-2014

	<i>Dependent variable:</i>	
	State Policy Conservatism	
	(1)	(2)
Efficiency Gap _{t-1}	-0.003*** (0.001)	-0.003*** (0.001)
Republican Governor _{t-1}	0.021*** (0.008)	0.023*** (0.008)
Republican Presidential Share		0.005*** (0.001)
Lagged Outcome	0.931*** (0.014)	0.903*** (0.015)
Year FEs	X	X
State FEs	X	X
Lagged Outcome Variable	X	X
Observations	813	813
R ²	0.991	0.992
Adjusted R ²	0.991	0.991
<i>Note:</i>	*p<0.1; **p<0.05; ***p<0.01	

6.2.4 Summary of Gerrymandering & Representation in State Government

Overall, the analyses in this section show that partisan bias in districting plans has large consequences for state government. States with pro-Republican bias in their districting plans have 1) more conservative state legislatures and 2) more conservative policy outcomes.

7 Conclusion

Based on my review of the literature and relevant data, I have reached a number of conclusions about Michigan's redistricting plan:

- There are substantially more wasted Democratic votes in Michigan congressional and state legislative elections than Republican votes. This has led to a substantial and durable Republican bias in the translation of votes to seats in congressional and state legislative elections in Michigan.

- Michigan's 2011 districting plan had one of the largest pro-Republican biases in history. The pro-Republican Efficiency Gap in Michigan's congressional districting plan is extremely large relative to other states. Michigan's congressional districts had a larger pro-Republican bias after its 2011 redistricting plan took effect in 2012 than 98% of the congressional election maps over the past 45 years. Its state house districts were more pro-Republican than 98% of previous plans and its state senate districts were more pro-Republican than over 99% of previous plans over the past five decades. Other gerrymandering measures show a similarly large pro-Republican bias in Michigan's plan.
- The pro-Republican bias in Michigan's plan cannot solely be a function of geography: Michigan's Efficiency Gaps in both its congressional and state legislative plans are much larger than its own Efficiency Gaps prior to the 2011 redistricting. Moreover, the declination measure, which its author claims is less influenced by geography than the Efficiency Gap, shows a huge pro-Republican bias in Michigan's congressional and state legislative election results after the 2011 plan went into place. Thus, the current Efficiency Gap in Michigan cannot solely be a product of geography.
- The pro-Republican advantage in congressional elections in Michigan causes Democratic voters whose votes are wasted to be effectively shut out of the political process in Congress. Due to the growing polarization in Congress, there is a large difference between the roll call voting behavior of Democrats and Republicans. In today's Congress, a representative from one party increasingly does not represent the views of a constituent of the opposite party. Thus, Democratic voters whose votes are wasted are unlikely to see their preferences represented by policymakers.
- Voters appear to be aware of the representational failure in Michigan's congressional districting plan. They are much less likely to trust their representatives than voters in states with smaller Efficiency Gaps. This suggests that gerrymandering is eroding Americans' faith in our democracy.
- The pro-Republican advantage in state legislative elections in Michigan skews roll call voting and policy outcomes in a conservative direction. The combination of partisan polarization and gerrymandering has led both roll call voting patterns and the policies passed by Michigan's government to be much more conservative than they would have been if Michigan had a neutral Efficiency Gap. Thus, the partisan bias in Michigan's state legislative plan is skewing its state government in a conservative direction.

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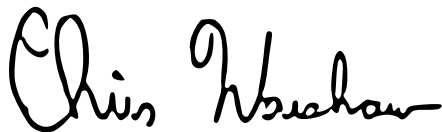
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A handwritten signature in black ink, appearing to read "Chris Hsueh". The signature is fluid and cursive, with the first name "Chris" and last name "Hsueh" clearly distinguishable.

June 1, 2018

Supplementary Appendix

A Measurement Model for Uncontested Races

A factor that complicates the computation of the Efficiency Gap (as well as any other measure of partisan bias) is that many seats are uncontested. As Stephanopoulos and McGhee (2015, 865) put it, “Since gerrymanders redistribute voters in order to pack and crack the opposition, determining the degree of packing and cracking requires knowing how many people in each district support each party.”³⁷ In uncontested races, however, it is not possible to calculate a two-party vote share. Thus, we have no way of knowing based on the election returns alone how many people supported each party.

If there were only a handful of uncontested races, this might not be an important problem. However, approximately 14% of congressional races between 1972-2016 were uncontested. In Michigan, about 4% of the congressional elections were uncontested between 1972-2016. In many states though there are much higher rates of uncontested elections. For instance, 34% of the congressional elections in Alabama during this period were uncontested and 41% of the elections in Massachusetts were uncontested. The problem is even more acute at the state legislative level, where about 39% of state house races were uncontested over the past 45 years.

As a result, we need some strategy to impute the two-party vote shares in these districts in order to estimate the Efficiency Gap. There are a variety of potential approaches to address this problem. The simplest strategy is to simply assume that the winning candidate receives 75% of the vote and the losing candidate receives 25% of the vote. Many political science studies have adopted this approach (e.g., Gelman and King 1994a; Kastellec, Gelman, and Chandler 2008).³⁸ However, Kastellec, Gelman, and Chandler (2008) point out that “there is no way to know whether the losing candidate would have actually received 25% of the vote. For example, in a heavily Democratic district in Philadelphia, this probably over-estimates the vote share a Republican candidate would have gotten. In contrast, it might under-estimate the Republican vote share in a more

37. A variety of other scholars have noted this problem. For instance, Campagna and Grofman (1990, 1247) note that “One key issue [for studies of redistricting] is how to handle uncontested seats. [One needs] to avoid using 100% as the vote share for a party in an uncontested seat (which, for Congress, tends to bloat ... vote share).”

38. Kastellec, Gelman, and Chandler (2008) justify this strategy by noting that King and Gelman (1991) and Gelman and King (1994a) examined the “vote shares received in the last election before a district became uncontested and the first election after a district became uncontested. The average of these values was about 0.75 for the incumbent party and represents the average ‘effective support’ for the party in uncontested races.”

suburban, swing district.”

A more sophisticated strategy to address uncontested races is to estimate the two-party vote share in district_{*i*} based on previous and future elections in that district as well as the results in similar districts elsewhere. A variety of recent analyses have used this approach. The Brennan Center’s recent report uses a variant of this approach for its estimates of Efficiency Gaps between 1992-2016 (Brennan Center 2017, 16).³⁹ This strategy is also used by the Public Policy Institute of California for its estimates of the Efficiency Gap over the last decade (McGhee 2018), and by Professor Simon Jackman in his expert reports for litigation in Wisconsin and North Carolina (Jackman 2015, 2017). One downside of this approach, however, is that it relies on less transparent assumptions than the simpler strategy described above.

Unfortunately, there are no publicly available, published estimates of the Efficiency Gap that span the past four decades for all three legislative chambers, including congressional, state house, and state senate districts. As a result, I build my own estimates using both approaches described above for imputing uncontested districts. That is, I build one set of Efficiency Gap estimates based on the assumption that the winning party receives 75% of the vote in uncontested districts and another version using a model that imputes the vote shares in uncontested districts based on previous and future elections in that district as well as the results in similar districts elsewhere. I use the latter estimates in the main body of the report. But it is important to note that the substantive results in the report are robust to the precise details of how we calculate the Efficiency Gap.

A.1 Overview of Data

A.1.1 Congressional Districts

For congressional districts, the foundation of my analysis was congressional election results from 1972-2014 collected by the Constituency-Level Elections Archive (CLEA) (Kollman et al. 2017). The results from 1972-1990 are based on data collected and maintained by the Inter-university Consortium for Political and Social Research (ICPSR) and adjusted by CLEA. The data from 1992-2014 are based on data collected by CLEA from the Office of the Clerk at the House of the Representatives. I supplemented this dataset with 2016 election results collected by the MIT Election and Data Science Lab (MIT Election and

39. Brennan Center (2017, 16) states that ‘For districts without both a Democrat and Republican running in the general election, we estimated the vote share both parties would have received in a contested two-party election based on the prior election’s House results, the most recent district-level Presidential results using totals calculated and compiled by Daily Kos Elections for both 2012 and 2016, a district’s Cook Partisan Voter Index, and the winning candidate’s incumbency status.’

Data Science Lab 2017). I used data on presidential election returns and incumbency status in Congressional elections collected by Professor Gary Jacobson (University of California, San Diego). This dataset has been used in many Political Science studies and has canonical status in the political science profession (Jacobson 2015). For the 2016 election, I used two data sources to supplement Jacobson's dataset. First, I obtained information on candidates' incumbency status from Hodges (2016). I obtained data on presidential election returns for the 2016 election aggregated by congressional district from the DailyKos website. I group elections by decade and estimate the Efficiency Gap for each state's plan in each election year.

A.1.2 State Legislative Districts

For state legislative districts, the foundation for my analysis was a large canonical data set on candidacies and results in state legislative elections from 1972-2016 collected by Carl Klarner and a large team of collaborators. The results from 1972-2012 are based on data maintained by the Inter-university Consortium for Political and Social Research (ICPSR) (Klarner et al. 2013). I obtained data from 2013-2016 directly from Klarner. I used a variety of sources of data on presidential election returns in state legislative districts. For elections between 1972 and 1991, I used data on county-level election returns from 1972-1988 collected by the Inter-university Consortium for Political and Social Research (ICPSR 2006) and mapped these returns to state legislative districts in order to estimate presidential, senate, and governor election results by state legislative district. For elections between 1992 and 2001, I used data on presidential election returns in the 2000 election collected by McDonald (2014) and Wright et al. (2009). For elections between 2002 and 2011, I used data on the 2004 and 2008 presidential elections collected by Rogers (2017). For elections between 2012 and 2016, I used data on presidential election returns for the 2012 and 2016 elections from the DailyKos website.

I group each state's elections based on its redistricting plan using data from Carl Klarner. In most cases, redistricting plans are constant over the course of a decade. However, a handful of states have redistricted mid-decade for various reasons. In general, I drop these states from my analysis. I also drop state legislative elections from my analysis where I am unable to match to data on presidential vote share. I also drop state senate elections in the first cycle after a redistricting from my analysis because it is not clear whether each district in the chamber is using the post-redistricting map.

Many state legislative elections are conducted in multimember districts. Previous studies have dropped the bulk of these districts from their analyses (e.g., Jackman 2015). However, I include multimember districts in my analysis of the Efficiency Gap in state

legislative elections. For multimember districts with posts, I treat each post as if it's a separate district. For multimember systems without posts, I match each winner with a maximum of one loser of the opposite party, and assume that they ran against each other in a post election. Specifically, I match the worst-performing winner with the best-performing loser of the opposite party, and then the next-worst performing winner with the second-best performing loser of the opposite party, etc. If there are more winners than losers, then there will be some “uncontested” races.

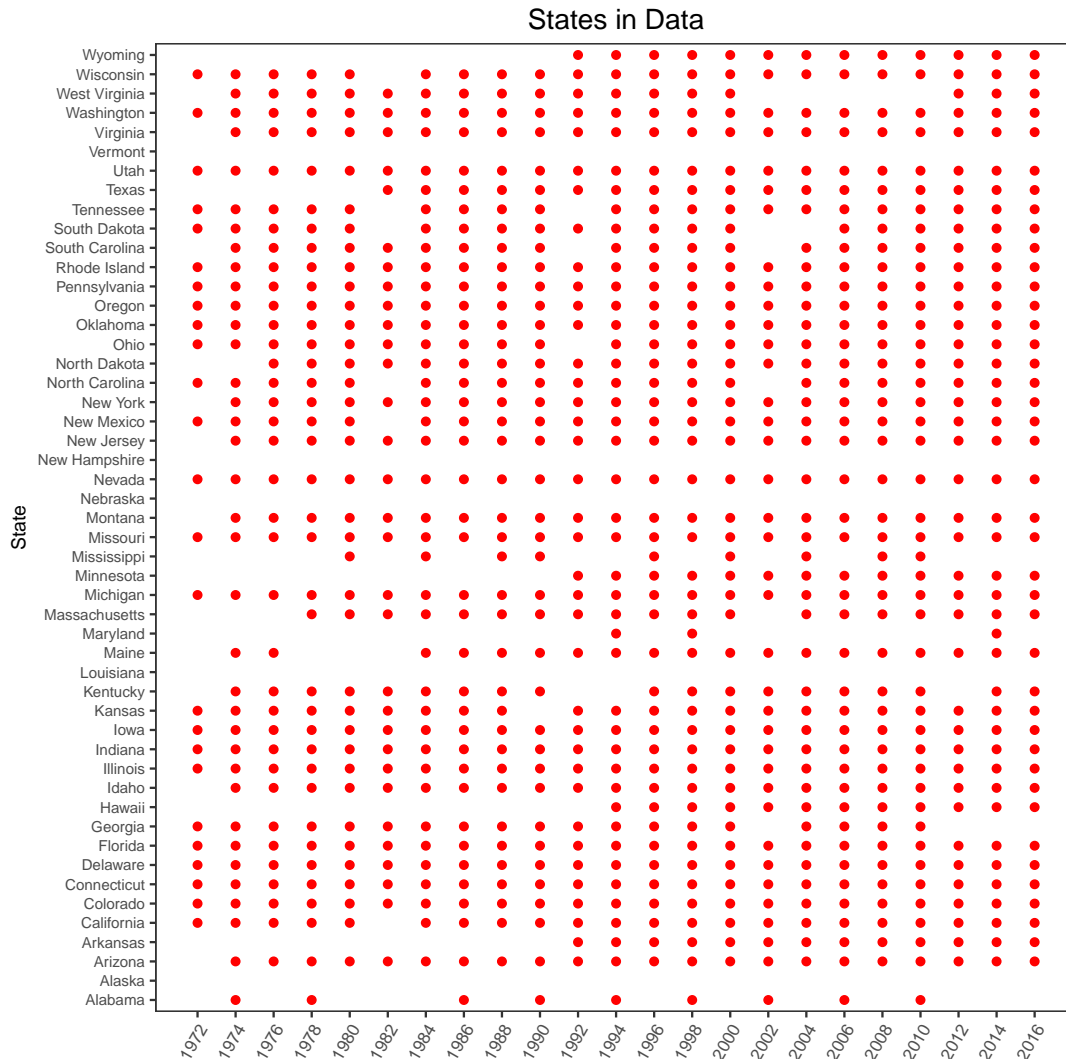


Figure A1: States and election cycles where I estimate the Efficiency Gap in State House Districts.

Finally, if only a portion of a state legislative chambers were elected in a particular year, I group these elections with the most recent previous election in each district in order to calculate each party's seat share, vote share, the number of wasted votes, the

Efficiency Gap, and other statistics.

Figure A1 (above) shows the states and election cycles where I estimate an efficiency gap for state house districts. Overall, I have estimated the Efficiency Gap for 896 of the 1123 (80%) state house election years in partisan legislatures between 1972 and 2016.⁴⁰ This is substantially more than previous analyses of gerrymandering in state legislatures using the Efficiency Gap (e.g., Stephanopoulos and McGhee 2015; Jackman 2015).

A.2 Details of Statistical Models

This section presents the details of the statistical models that I use to impute uncontested races.

1. First, I estimate the Efficiency Gap assuming that the winner in uncontested races receives 75% of the vote and the loser receives 25% of the vote. I estimate the statewide Democratic vote share by assuming that turnout in each district was equal and simply taking the average of the two-party vote shares in each district.
2. Second, I estimate the Efficiency Gap using a statistical model to impute both the vote share and turnout in uncontested districts. This model is closely related to the imputation strategy for uncontested districts adopted by previous studies of the Efficiency Gap (Stephanopoulos and McGhee 2015; Jackman 2015, 2017; Brennan Center 2017; McGhee 2018).
 - In order to estimate the vote shares in uncontested districts, I model the proportion of the two-party vote received by the Democrat ($p_{d,t}$) in each district (d) using a binomial model.

$$s_{d,t}^v \sim \text{Binomial}(n_{d,t}^v, p_{d,t}^v), \quad (3)$$

where d indexes districts and t indexes elections. $n_{d,t}^v$ is set to 2000⁴¹ and $s_{d,t}^v$ is the two-party vote share multiplied by 2000. For uncontested races, we set $n_{d,t}^v$ and $s_{d,t}^v$ to zero. We then model p as a function of: previous and future results in that district, each district's presidential vote share, whether there

40. I have dropped state-years for the following reasons. First, I drop state-years where I am unable to match presidential election results to state legislative districts. Second, I drop state-years that precede a mid-decade redistricting.

41. This number is set for computational efficiency. However, it could be arbitrarily set to some other number, and this would not affect the model results.

is an incumbent running, and if so, their party, and the region (congressional districts) or state (state legislative districts) that the district is in. For state legislative races, I also include the Democrats' vote share in governors and senate races during the 1970s and 1980s as a predictor since state legislative races during this period were less nationalized than in more recent decades. More formally, for congressional districts, we model

$$p_{d,t}^v = \Phi(\gamma_t + p_{d,t-1}^v + \beta_1 * pvote_{d,t} + \beta_2 * incumbency_{d,t} + \alpha_{s[d]}^{region}) \quad (4)$$

where *pvote* is the percentage of the two-party presidential vote received by the Democratic candidate in each district; *incumbency* is a factor equal to 1 if there is a Democratic incumbent, 0 if there is no incumbent, and -1 if there is a Republican incumbent; regions are based on economic regions defined by the Bureau of Economic Advisors; and the normal CDF Φ maps p to the (0, 1) interval. I estimate the model separately each decennial redistricting period (i.e., years ending in 02 - 12) using the `dgmpr` function in the `dgo` package in **R** (Dunham, Caughey, and Warshaw 2016).⁴² The mean estimate of Democratic vote share in uncontested congressional races won by Democrats is 71% and the average estimate of Democratic vote share in uncontested races won by Republicans is 31%.⁴³

- In order to estimate the turnout in uncontested congressional districts, I model the proportion of the population ($p_{d,t}$) that votes in each district (d) using a similar binomial model.

$$s_{d,t}^t \sim \text{Binomial}(n_{d,t}^t, p_{d,t}^t), \quad (5)$$

where $n_{d,t}^t$ is set to 2000 and $s_{d,t}^t$ is the proportion of the population that voted for either the Democratic or Republican candidate multiplied by 2000. For districts with uncontested races, we set $n_{d,t}^t$ and $s_{d,t}^t$ to zero. We then model p as a function of: previous and future results in that district, whether there is an incumbent running, and if so, their party, and the region that the district

42. Due to data limitations, for both the models of turnout and vote share in congressional elections, I do not split apart states' plans due to mid-decade redistrictings. In recent decades, however, only a handful of states have conducted mid-decade redistrictings. For state legislative districts, I drop elections from districting plans established prior to a mid-decade redistricting.

43. These estimates are very similar to those of Stephanopoulos and McGhee (2015, 866). Based on a similar approach, they estimate a "mean Democratic vote share [in uncontested races] of 70 percent," and for uncontested Republicans, they estimate "a mean Democratic vote share of 32 percent."

is in. More formally, we model

$$p_{d,t}^t = \Phi(\gamma_t + p_{d,t-1}^t + \beta_1 * incumbency_{d,t} + \alpha_{s[d]}^{region}) \quad (6)$$

where *incumbency* is a factor equal to 1 if there is a Democratic incumbent, 0 if there is no incumbent, and -1 if there is a Republican incumbent; regions are based on economic regions defined by the Bureau of Economic Advisors; and the normal CDF Φ maps p to the $(0, 1)$ interval. I estimate the model separately each decennial redistricting period (i.e., years ending in 02 - 12) using the `dgmnp` function in the `dgo` package in **R** (Dunham, Caughey, and Warshaw 2016).

- In order to estimate the turnout in uncontested state legislative districts, I take the average of the turnout in district_{*d*} in other presidential or midterm years in a given decade. If no data on district_{*d*} is available, I take the average of turnout in year_{*t*} elsewhere in the state. I use this simpler approach due to the unavailability of population data for state legislative districts.
- Finally, for uncontested congressional and state legislative districts, I estimate the number of Democratic votes in each district by multiplying the estimated, imputed Democratic vote share ($p_{d,t}^v$) by the estimate of the total turnout. For contested districts, I use the actual number of Democratic votes and total votes in each district. Combining these approaches, I estimate the statewide Democratic vote share by simply summing the Democratic votes in each district and dividing by the total number of votes.

Now that we know voters' two-party preferences in contested districts and we have estimates of their preferences in uncontested districts, we are finally in position to estimate the partisan advantage in the congressional and state legislative districting process during each state-year. I estimate the efficiency gap in all states for each election between 1972 to 2016 using equation 2.⁴⁴

In the discussion of congressional districts in the main body of the report, I focus on states with more than 6 congressional seats. I omit smaller states for two reasons. First, these states contribute less to the overall distribution of seats in Congress (Stephanopoulos and McGhee 2015, 868). Second, the Efficiency Gap in smaller states tends to be more volatile and thus less informative about partisan bias. For example, in a state with only

44. I start the analysis in 1972 since those are the first districting plans drawn after the Supreme Court cases stemming from *Baker v. Carr* ended malapportionment and established the principle of one-person, one-vote.

three seats, a change in the winner of one seat could cause a huge shift in their Efficiency Gap.

A.3 Validation

Prior to examining our results, it is useful to validate my measures of the Efficiency Gap to make sure that it aligns closely with alternative modeling approaches for uncontested races. In fact, Figure A2 shows that the precise method used to impute uncontested congressional races makes relatively little difference for estimates of the Efficiency Gap.

- The correlation between estimates of the Efficiency Gap for congressional districts I calculated using the Bayesian method described above and a simpler approach that assumes the winner in uncontested races received 75% of the two-party vote is 0.95.
- The correlation between my estimates of the Efficiency Gap for congressional districts and estimates for 1992-2016 developed by the Brennan Center is 0.95.
- The correlation between my estimates of the Efficiency Gap for congressional districts and estimates for 2002-2016 developed by the Public Policy Institute of California is 0.98.

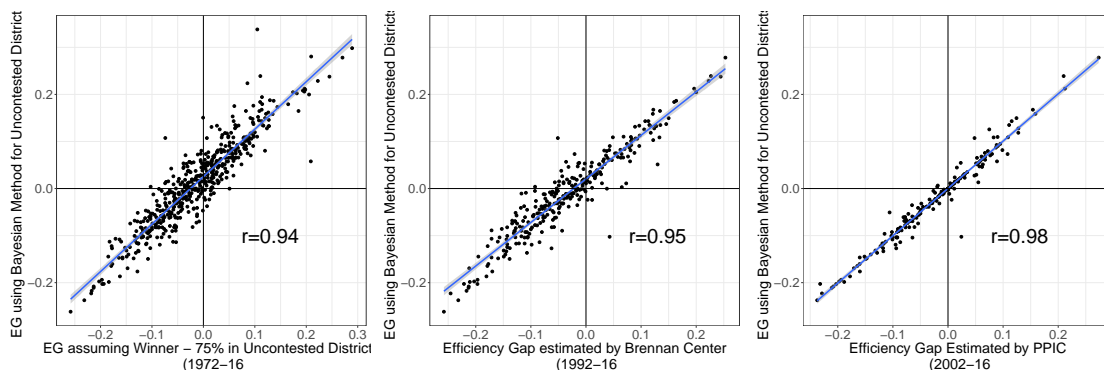


Figure A2: Validation of the Efficiency Gap Measure for Congressional Elections

I also find very high correlations between my estimates of the Efficiency Gap in state house districts and other modeling approaches for estimating the Efficiency Gap.

- The correlation between estimates of the Efficiency Gap for congressional districts I calculated using the Bayesian method described above and a simpler approach that assumes the winner in uncontested races received 75% of the two-party vote is 0.84.

- The correlation between my estimates of the Efficiency Gap for congressional districts and estimates for 1972-2014 developed by Jackman (2015) is 0.91.⁴⁵
- I also find very high correlations between my estimates of the Efficiency Gap and the declination measures discussed in the main body of the report.

45. It is important to note that my methodology for estimating the Efficiency Gap differs from Jackman (2015)'s approach in three relatively minor ways which slightly attenuates the correlation between our measures. First, I adjust for unequal turnout across districts. If I do not adjust for differences in turnout, my Efficiency Gap estimates have a 0.96 correlation with Jackman's estimates. Second, I use presidential vote share as a predictor of state legislative elections throughout the entire time period to estimate uncontested districts. Finally, I include states with multimember districts in my analysis.

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Research Interests

American Politics, Representation, Public Opinion, State & Local Politics, Environmental Politics and Policy, Statistical Methodology

Research

Published Articles

Peer Reviewed Articles

1. "The Ideological Nationalization of Party Constituencies in the American States". Forthcoming. *Public Choice*. Keith Poole Symposium. (with James Dunham and Devin Caughey)

2. "On the Representativeness of Primary Electorates." Forthcoming. *British Journal of Political Science* (with John Sides, Chris Tausanovitch, and Lynn Vavreck)
3. "Geography, Uncertainty, and Polarization." Forthcoming. *Political Science Research and Methods*. (with Nolan McCarty, Jonathan Rodden, Boris Shor, and Chris Tausanovitch)
4. "Policy Preferences and Policy Change: Dynamic Responsiveness in the American States, 1936-2014." 2018. *American Political Science Review*. 112(2): 249-266. (with Devin Caughey)
5. "Does the Ideological Proximity Between Candidates and Voters Affect Voting in U.S. House Elections?" 2018. *Political Behavior*. 40(1): 223-245. (with Chris Tausanovitch)
6. "Partisan Gerrymandering and the Political Process: Effects on Roll-Call Voting and State Policies." *Election Law Journal*. December, 2017. 16(4): 453-469. Symposium on Partisan Gerrymandering and the Efficiency Gap. (with Devin Caughey and Chris Tausanovitch)
7. "Incremental Democracy: The Policy Effects of Partisan Control of State Government." 2017. *Journal of Politics*. 79:4. (with Devin Caughey and Yiqing Xu)
8. "Renewable energy policy design and framing influences public support in the United States." 2017. *Nature Energy*. 2(17107). (with Leah Stokes)
9. "Estimating Candidates' Political Orientation in a Polarized Congress." 2017. *Political Analysis*. 25(2). (with Chris Tausanovitch)
10. "The Dynamics of State Policy Liberalism, 1936-2014." 2016. *American Journal of Political Science*. 60(4). (with Devin Caughey)
11. "Mayoral Partisanship and Municipal Fiscal Policy." 2016. *Journal of Politics*. 78(4). (with Justin de Benedictis-Kessner).
12. "Dynamic Estimation of Latent Opinion Using a Hierarchical Group-Level IRT Model." 2015. *Political Analysis*. 23(2). (with Devin Caughey)
13. "Representation in Municipal Government." 2014. *American Political Science Review*. 108(3). (with Chris Tausanovitch)
14. "Measuring Constituent Policy Preferences in Congress, State Legislatures and Cities." 2013. *Journal of Politics*. 75(2). (with Chris Tausanovitch)
15. "How Should We Measure District-Level Public Opinion on Individual Issues?" 2012. *Journal of Politics*. 74(1). (with Jonathan Rodden)

Book Chapters, Book & Article Reviews, and Law Review Articles

1. "Spatial variation in messaging effects." Forthcoming. *Nature Climate Change*. News & Views. April, 2018.
2. "Latent Constructs in Public Opinion." Forthcoming. *Oxford Handbook on Polling and Polling Methods*. R. Michael Alvarez and Lonna Atkeson, ed. Oxford: Oxford University Press.
3. "The Application of Big Data in Surveys to the Study of Elections, Public Opinion, and Representation." 2016. *Data Analytics in Social Science, Government, and Industry*. R. Michael Alvarez, ed. Cambridge: Cambridge University Press.
4. "The Political Economy of Expropriation and Privatization in the Oil Sector." 2012. *Oil and Governance: State-Owned Enterprises and the World Energy Supply*. David G. Victor, David Hults, and Mark Thurber, eds. Cambridge: Cambridge University Press.

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5. "Democratization and Countermajoritarian Institutions: The Role of Power and Constitutional Design In Self-Enforcing Democracy." 2012. *Comparative Constitutional Design*. Cambridge: Cambridge University Press. (with Susan Alberts and Barry R. Weingast).
6. "Business as Usual? Analyzing the Doctrinal Development of Environmental Standing Doctrine since 1976." 2011. *Harvard Law and Policy Review*. Volume 5.2. (with Gregory Wannier).

Unpublished Articles

Under Review

- "Ideology in the European Mass Public: A Dynamic Perspective" (with Devin Caughey and Tom O'Grady) (R&R)
- "Politics in Forgotten Governments: The Partisan Composition of County Legislatures and County Fiscal Policies" (with Justin de Benedictis-Kessner) (R&R)
- "Beyond politics: Climate concern responds to changing temperatures in the American states" (with Parrish Bergquist) (R&R)

Works in Progress

- Book Project: "Dynamic Democracy: Citizens, Politicians, and Policymaking in the American States, 1936-2015" (with Devin Caughey)
- "Responsiveness and Election Proximity in the United States Senate"
- "Economic Voting in Gubernatorial Elections"
- "Urban Elections and Representation" (Invited submission for the 2019 Annual Review of Political Science)

Teaching Experience

Instructor:

- Multi-level and Panel Models (Graduate-level) (GW), 2017
- Public Opinion (GW), 2017
- American Political Institutions (Graduate-level) (MIT), 2014, 2016
- Public Opinion and Elections (MIT), 2016
- Energy Policy (MIT), 2013
- Democracy in America (MIT), 2013, 2014
- Constitutional Law & Judicial Politics (MIT), 2013, 2015
- Making Public Policy (MIT), 2012, 2014

Teaching Assistant:

- Introduction to American Law (Stanford University), 2010
- Judicial Politics and Constitutional Law (Stanford University), 2009

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Political Economy of Energy Policy (Stanford University), 2008
Introduction to International Relations (Stanford University), 2008
Introduction to Public Policy (Stanford University), 2007
Introduction to Econometrics (Williams College), 2002

Invited Talks

2017-2018: BYU, University of Chicago Conference on Political Polarization
2016-2017: University of Virginia; UCLA
2015-2016: Washington University in St. Louis; Texas A&M; Arizona State University Conference on Campaigns, Elections and Representation
2014-2015: Yale; Columbia; Duke
2013-2014: Princeton; Boston University; Rochester University
2012-2013: MIT American Politics Conference; Columbia Representation Conference; Princeton Media & Politics Conference; Annual Meeting of the Society for Political Methodology

Grants

Jeptha H. and Emily V. Wade Award (\$59,686)
MIT Energy Institute (MITEI) Seed Grant (\$137,147)
MIT SHASS Research Fund (\$8,734)

Awards and Honors

APSA award for best journal article on State Politics & Policy in 2016.
Award for best paper on State Politics & Policy at the 2014 American Political Science Conference.
Graduate Fellowship, Dept. of Political Science, Stanford University, 2006-2012
David A. Wells Prize in Political Economy for Best Undergraduate Economics Thesis, Williams College, 2002
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University Service

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Member, Energy Education Task Force, 2012-2017
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Faculty Fellow, Burchard Scholars, 2013-2015

Stanford University:

President, Stanford Environmental Law Society, 2009-2010

Executive Board Member, Stanford Environmental Law Society 2008-2010

Member, University Committee on Graduate Studies, 2007-2009

Member, University Library Committee, 2007-2008

President, Political Science Graduate Students Association, 2007-2008

Professional Service

Reviewer: American Political Science Review, American Journal of Political Science, Journal of Politics, Political Analysis, Political Behavior, Econometrica, Quarterly Journal of Political Science, Legislative Studies Quarterly, Political Research Quarterly, American Politics Research, British Journal of Political Science, Journal of Law and Courts, Public Opinion Quarterly, Political Science Research and Methods, State Politics and Policy Quarterly, Journal of Experimental Political Science, Nature Climate Change, Urban Affairs Review, Journal of Health Politics, Policy and Law, Perspectives on Politics, Cambridge University Press

Member, Planning Committee, Cooperative Congressional Election Study (CCES), 2018

Member, Best Paper Committee, State Politics Section of the American Political Science Assoc., 2018

Editorial Board, Journal of Politics, 2017-

Executive Committee, Urban Politics Section of the American Political Science Association, 2015-2017

Member, Best Paper Committee, Urban Politics Section of the American Political Science Assoc., 2015

Consulting

Expert, *League of Women Voters of Pennsylvania v. the Commonwealth of Pennsylvania*, Partisan Gerrymandering Case (2017-18)

Expert, *League of Women Voters of Michigan v. Johnson*, Partisan Gerrymandering Case (2018)

Community Service

Sierra Club: National Board of Directors (2009-2015)

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